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MAJOR TASK AND KNOWLEDGE CLUSTERS INVOLVED IN PERFORMANCE OF ELECTRONIC TECHNICIANS' WORK.

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AN EFFORT WAS MADE TO IDENTIFY SPECIFIC KNOWLEDGES AND CLUSTERS OF KNOWLEDGES MOST WIDELY USEFUL IN MAJOR TYPES OF WORK COMMONLY DONE BY ELECTRONIC TECHNICIANS. PRINCIPAL TASKS OF TECHNICIANS WERE CLASSIFIED AS (1) DIAGNOSING TROUBLE IN SYSTEMS, (2) ADJUSTING AND OPERATING, (3) SERVICING, (4) ASSEMBLING, (5) INSTALLING, (6) DESIGNING AND COMPUTING, (7) APPLICATION, DISTRIBUTION, AND SALES IN ELECTRONICS, AND (8) QUALITY CONTROL AND TESTING. A QUESTIONNAIRE LISTING 643 KNOWLEDGES EXTRACTED FROM TEXTBOOKS, CURRICULUM GUIDES, AND COURSES OF STUDY WAS ADMINISTERED TO A SAMPLE OF WORKERS IN 64 ESTABLISHMENTS BROADLY REPRESENTATIVE OF THE NATIONAL PATTERN OF ELECTRONIC TECHNICIANS' WORK. THESE WORKERS DEEMED 84 OF THE 643 KNOWLEDGES ESSENTIAL FOR PERFORMANCE OF SIX OF THE EIGHT PRINCIPAL TASKS, AND 154 ESSENTIAL FOR PERFORMANCE OF THREE TO FIVE PRINCIPAL TASKS. THESE DATA WERE PROVIDED BY 154 USABLE QUESTIONNAIRES. THIS VOLUME REPRESENTS PART 4 OF THE 13-PART FINAL REPORT ON THE VOCATIONAL-TECHNICAL EDUCATION RESEARCH AND DEVELOPMENT PROJECT OF WASHINGTON STATE UNIVERSITY. RELATED REPORTS ARE ED 010 652 THROUGH ED 010 664. (JH)

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Project No. ERD-257-65
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by

Boyd C. Mills
Under direction of Harold F. Rahmlow

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INTRODUCTION

Background and Rationale

Constantly, new occupations emerge from the development of electronic knowledge and equipment. Electronics has developed in sophistication and reliability to such an extent that applications are widespread. Electronic knowledges are utilized by growing numbers of workers. In the past such workers have been drawn from many sources, but today they are being increasingly trained in schools and colleges. Originally, scientists and engineers provided assistants with understandings necessary to assist with electronic work. As electronics became more widely applied, a shortage of highly trained engineers and scientists developed. As engineers became more highly trained in mathematics and science, a steadily widening gap between them and electronic assistants emerged. Today, fuller utilization of engineers and scientists requires a more adequate supply of technical workers. Such personnel need knowledge and skills essential for application of theoretical principles. This middle range of technical tasks is generally performed by technicians.

Electronics is a rapidly changing field. New devices and processes constantly emerge. Schools seeking to meet present-day needs are confronted with problems of adjusting, deleting, and adding material in order to satisfactorily train students for employment. Some electronic workers have become specialized, requiring additional training in various aspects of electronics not required for all workers. These factors complicate the problem of providing useful training.

Work force mobility affects the content of instruction. Technicians trained in one locality seek and obtain employment in other distant localities. Consequently, schools are faced with the additional problem of preparing students for work in other geographic regions where requirements may differ from those of local firms. Under these circumstances, all local curriculum planners have need for information about knowledges and skills most generally useful in the electronics industry.

Purpose and Hypothesis

The purpose of this study is to identify specific knowledges and clusters of knowledges most widely utilized in major types of work commonly done by electronic technicians.

It is hypothesized that many of the knowledges required for work in electronic technician occupations will be essential for effective performance of a substantial portion of major tasks. It is assumed that identification of commonly useful knowledges will provide a partial base for curriculum development.

REVIEW OF RELATED RESEARCH

Definitions of "Technicians"

Numerous researchers have noted the difficulty of defining a "technician" due to the wide range of positions to which the term is applied. The term is generally used to denote workers who perform a wide range of tasks under various conditions. This diversity of functions has caused considerable variation in definitions. Some authorities derive definitions from the work performed; others formulate definitions oriented to training required for particular types of work. Regardless of which basis is used, at least three levels, or types, of technicians may be identified: the engineering technician, the industrial technician, and the technical specialist.

The technician who serves directly under the supervision of an engineer or scientist in the performance of duties is often termed an engineering technician. He may carry a number of job titles and classifications as determined by employers. He is normally trained in mathematics and science, particularly physics, beyond the high school level. He is skilled in processes and methods of industry and performs tasks of considerable complexity.

The technician who is somewhat further removed from scientific supervision and performs his duties in areas more closely related to production is often termed an industrial technician. Such technicians, operating under general but indirect supervision of engineers and scientists, generally perform tasks involving measurement, construction, and layout. These functions require a knowledge of scientific and mathematical principles similar to, but differing in degree from, those of engineering technicians.

The technicians who are most remote from supervision of engineers and scientists are the technical specialists. They have need for a more specific knowledge of scientific principles necessary to perform somewhat more specific tasks. They may perform their functions with little or no scientific direction, except in the form of occasional written instruction or directions. Due to the nature of their work, remote from scientific direction, they, of necessity, need considerable knowledge of scientific principles of a specialized nature in addition to general knowledges.

Harris[1] notes the imprecise use of the term "technician." Swanson and Kramer provide a definition based on the job requirements and activities of technical workers.

The activities as technician require a person:

a. to possess and use extensive specialized knowledge and/or
b. to make very accurate measurements, and/or
c. to use delicate and complex instruments, and/or

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[1]Norman C. Harris, "Content Distribution in Engineering-Related and Industrial-Related Technician Curriculums," Selected Papers (Washington: American Association of Junior Colleges, 1964). (Mimeographed.)

d. to accept unusual responsibilities for the safety and welfare of persons and equipment.

The technician works:

a. directly as an assistant to a very highly skilled person, or
b. in a process or with equipment developed by a very highly skilled person.[1]

In terms of electronics, these requirements identify any electronic worker performing tasks involving advanced electronic knowledges and performing a wide range of tasks.

The term technician is widely used in the Dictionary of Occupational Titles.[2] While the principal classification of the electronic technician is 003.181, Electronic Technician, specific uses of the title reflect a range of functions performed by specialized technicians. Titles include: Electronic Scale Assembler, 825.251; Electronics Assembler, 726.781; Electronics Technician, Automated Process, 726.281; and Commercial Engineer (Radio and Television Broadcast), 003.187.

The broad range of training and functions is reflected in the study of the United States Office of Education that serves as a base for a course of study in Electronic Technology:

> Graduates of Electronic Technology may work in two broad areas--the field of communications (where they specialize in radio, radar, and television) or in manufacturing (where they specialize in design, modification, and installation of complex electronic units used in controlling and activating various mechanical systems, such as analog or digital computers, serve-machanisms, missile guidance systems, and machine tools; in evaluating the operating characteristics of electronic equipment; or in performing trouble-shooting functions to locate and correct malfunctioning of electronic equipment.)[3]

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[1] J. Chester Swanson and Ernest G. Kramer, "Vocational Education Beyond the High School." Vocational Education, ed. Melvin Barlow, Part I, Sixty-fourth N.S.S.E. Yearbook (Chicago: University of Chicago Press, 1965), p. 176.

[2] U. S. Department of Labor, Office of Manpower Administration, Dictionary of Occupational Titles, Vol. I and II (Washington: Government Printing Office, 1965).

[3] U. S. Department of Health, Education, and Welfare, Office of Education, Electrical and Electronic Technologies: Job Descriptions and Suggested Techniques for Determining Courses of Study in Vocational Education Programs, OE-80004 (Washington: Government Printing Office, 1960).

In a study of navy electronics workers Schultz and Siegel[1] identified four types of tasks of differing nature. Using factor analysis, they showed wide spearations of tasks ranging from routine to complex. They classify tasks into categories of electro-comprehension, routine operation and inspection, electro-repair, and electro-safety.

The United States Office of Education[2] recognizes the following eight task areas for Electronic Technicians in a publication to assist schools in constructing courses of study: Research Technician, Electronic Systems; Electronic Layout Technician; Electronic Technician, Multiplexing; Electronic Technician, Printed Circuits; Electronic Technician, Telemetering; Instrumentation Technician, Electronic; Test Technician, Guidance Systems; and Transducer Development Technician. For these classifications of workers, no differences of training in electronics was suggested.

Emerson[3] identified nine areas of work in which technicians are employed: Research, Design, Development, Testing, Manufacture, Sales, Installation, Operation, and Service.

The Bureau of Labor Statistics has prepared the following definition in terms of training.

> All persons engaged in work requiring a knowledge of physical, life engineering, and mathematical sciences comparable with knowledge acquired through technical institute, junior college, or other formal post-high school training or through equivalent on-the-job training or experience. Some typical job titles are: Laboratory assistants, Physical aids, and Electronics technicians. All employees in positions requiring the indicated levels of knowledge and training should be included regardless of job title and company department in which employed. Exclude craftsmen such as machinists and electricians.[4]

The President's Committee on Scientists and Engineers has produced a comparable definition in terms of technicians' functions.

> The engineering or scientific technician is usually employed in (1) research, design or development; (2) production, operation or control; (3) installation, maintenance or sales. When serving

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[1]Douglas G. Schultz and Arthur I. Siegel, "The Analysis of Job Performance by Multi-Dimensional Scaling Techniques," Journal of Applied Psychology, 48 (October, 1964), 329-335.

[2]U. S. Office of Education, OE-80004.

[3]Emerson, p. 16.

[4]U.S. Bureau of Labor Statistics, The Long Range Demand for Scientific and Technical Personnel: A Methodological Study, Prepared by the U. S. Department of Labor for the National Science Foundation, N.S.F. 61-65.

> in the first of these functional categories, he usually follows a course prescribed by a scientist or engineer but may not work closely under his direction. When active in the third category, he is frequently performing a task that would otherwise have to be done by an engineer.
>
> In executing his function, the scientific or engineering technician is required to use a high degree of rational thinking and to employ postsecondary school mathematics and principles of physical and natural science. He thereby assumes the more routine engineering functions necessary in a growing technologically based economy. He must effectively communicate scientific or engineering ideas mathematically, graphically, and linguistically.[1]

Either a definition based on the preparation of the technician, or one based on the duties or tasks he performs affords meaning to schools in terms of preparation and to employers in terms of employment. It is desirable to limit the definitions to workers who have training backgrounds equivalent to those being prepared by schools to assure useful application of findings of the study. Similarly, it is useful to limit the definition to positions in which schools may normally expect to place their graduates.

Both definitions quoted above describe a worker who makes applications of principles of science in the performance of technical tasks. In this report, therefore, electronic technicians are defined as those workers who possess a knowledge of certain electronic principles acquired through post-high school study or its equivalent and who perform tasks requiring an application of such knowledge. This definition permist identification of the tasks performed and identification of the knowledges utilized by technicians.

Knowledge--This study identifies items of information adjudged needed by employed technicians. Bloom and his colleagues have defined knowledge in a useful way:

> Knowledge, as defined here involves the recall of specifics and universals, the recall of methods and processes, or the recall of a pattern, structure, or settings.... In an analysis of the various knowledges, those of specifics, terminology, specific facts, ways and means of dealing with specifics, conventions, criteria, methodology, universals, and abstractions, principles and generalizations and theories are included.[2]

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[1] U.S. Department of Health, Education and Welfare, Office of Education, Organized Occupational Curriculums in Higher Education (Washington, D.C.: Office of Education, 1961), p. 3.

[2] Benjamin S. Bloom (ed.), Taxonomy of Educational Objectives, Handbook I, The Cognitive Domain (New York: David McKay Co., 1956), pp. 201-204.

That definition is utilized for this study.

Skill--Good defines skill as "anything that the individual has learned to do with ease and precision. It may be either a physical or mental performance."[1] This definition is used in this study.

Principle--Bloom and his colleagues define the term as pertaining to generalizations. "These are abstractions which are of greatest value in explaining, describing, predicting, or in determining the most appropriate and relevant action or direction to be taken."[2] Principles of operation of electronic devices imply those electronic principles which underlie the utilization of an electronic abstraction. This definition is used for this study.

Principal tasks--For this study this term is defined as tasks most commonly performed by technicians in industries in which major percentages of such workers are employed. This term is used to conceptualize various clusters of tasks performed. If, for examp e, a technician is engaged mainly in repairing devices or replacing faulty components, his principal task is defined as that of servicing. All other tasks associated with repair or component replacement are classified as service functions. If the technician services more than one-half time, that is considered to be his principal task.

Studies of Knowledge Needed for Work

The Second Annual Report of the Secretary of Health, Education, and Welfare to the Congress noted that:

> Manpower training programs too often have identified employment opportunities in narrowly defined occupations.... These specialized courses have the advantage of allowing the training to be rapid and relevant to specific opportunities in the local community. However, individuals trained in a group of related skills in general occupational fields have a wider opportunity for obtaining employment and can more easily adapt to changing job requirements than those given narrow occupational training.[3]

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[1]Carter V. Good, Dictionary of Education (New York: McGraw-Hill Book Co., 1959).

[2]Benjamin S. Bloom (ed.), Taxonomy of Educational Objectives, Handbook I, The Cognitive Domain (New York: David McKay Co., 1956), pp. 75.

[3]U. S. Department of Health, Education, and Welfare, Education and Training: Key to Development of Human Resources, Second Annual Report to the Congress of the Secretary of Health, Education, and Welfare, April 1, 1964, p. 41.

This emphasis on breadth of training is intended to increase adaptability of the worker in the changing job world.

Most studies devised to determine occupational curriculum have followed a time-tested format. The occupation is defined, a job or position analysis is performed, and skills and knowledges are abstracted from the identified tasks performed by the workers. Shartle has written a concise procedure for occupational analysis.[1] He examines methods of analysis and through the use of examples shows the methods for testing and procedures for occupational grouping. The outcome of such analysis is a list of tasks, which may be used to form the basis for educational planning. On bases of such task descriptions, educators must build educational plans to teach abilities required for employment.

The United States Office of Education identified broad categories of knowledges as advisable or essential for certain types of electronic technologists.[2] Job descriptions were related to very specialized tasks which would serve a limited portion of the employed technicians.

Fields notes that occupations tend to push up the educational ladder, and that technical occupations become increasingly complex.[3] Curricula should stress principles which can be used in settings of change over extended periods of time. Arnstein agrees with this concept of increasing complexity.[4] He suggests that the manual and manipulative aspects of the occupations may be of lesser importance than the skills and knowledges which are likely to be useful over a long period of time under conditions of change.

Roney analyzed the interrelationship of mathematics, science, and other subject matter in certain technical institutes.[5] He studied 35 curricula

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[1]Carroll L. Shartle, "Occupational Analysis, Worker Characteristics, and Occupational Classification Systems," Man in a World at Work, ed. Henry Borow (Boston: Houghton Mifflin Co., 1964), pp. 285-309.

[2]U.S. Department of Health, Education, and Welfare, Office of Education, Electrical and Electronic Technologies: Job Descriptions and Suggested Techniques for Determining Courses of Study in Vocational Education Programs, OE-80004 (Washington: Government Printing Office, 1960).

[3]Ralph R. Fields, The Community College Movement (New York: McGraw-Hill Book Co., 1962), p. 301.

[4]George E. Arnstein, "The Technological Context of Vocational Education," Vocational Education, ed. Melvin Barlow, Part I, Sixty-fourth N.S.S.E. Yearbook (Chicago: University of Chicago Press, 1965), p. 61.

[5]Maurice W. Roney, "An Analysis of the Interrelationship of Mathematics, Science, and Subject Matter in Selected Technical Institute Curricula" (unpublished Ed.D. dissertation, University of Maryland, 1964).

from 12 technical institutes. In this research, ways of coordinating instruction in mathematics and science with the technical instruction were illustrated. The curricula analyzed included electronics technology. His method assists schools in improving related instruction in mathematics and science for electronic technician training programs.

Schill[1] devised a special method of using Q-sort technique to determine the necessary mathematics content for students in electronics in certain California schools.

In another application of the Q-sort technique Schill[2] examined the knowledges related to certain technologies. His sample was drawn from selected industries in the state of Illinois. The study utilized cards bearing descriptions of subject matter similar to course descriptions used in schools. Subjects sorted cards bearing these descriptions, choosing those cards thought to be most related to their work. A factor analysis was performed, and as a result, a core program was identified. He also identified potential programs in Electronic, Electro-Mechanical, Mechanical, Chemical-Mechanical, Chemical, and Electro-Chemical Technologies. Knowledges functionally related to all the technologies were found to include technical writing, engineering graphics, mathematics through trigonometry, and the use of test equipment. The knowledges specific to electronics were identified through seven card descriptions. This research provides a descriptive picture of the technician, his functions in manufacture, his educational background, and his occupational background.

Substantial concurrence of technician and management judgments about knowledges relating to technical work was found by Schill and Arnold.[3] They reported agreement to be strong on items assessed on an index of specificity--generality. They obtained an $r = 0.959$ as a measure of agreement between managers and employees, which exceeded the 0.001 probability level.

The relationship between what a technician must know and what he does has been studied by Phipps and Fuller who used a principle axis factor analysis with varimax rotation to cluster certain occupations in a study of industrial technical needs in Illinois. They said, in part: "Clusters of job titles, for example with a relatively high factor score for an 'x'

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[1]William J. Schill, "The Use of the Q-Technique in Determining Curriculum Content," California Journal of Educational Research, 12 (September, 1961), 178-184.

[2]William J. Schill, Curricula Content for Technical Education, College of Education, University of Illinois, and U.S. Office of Education, Cooperative Research Project 2048.

[3]William J. Schill and Joseph P. Arnold, Curricula Content for Six Technologies, College of Education, University of Illinois, Urbana, 1965, pp. 61-91. (Mimeographed.)

factor of activities and a 'y' factor of knowledge areas will provide considerable information helpful in designing curricula for technicians and other workers needing some technical education."[1]

Walsh and Selden concluded that more research in what knowledges are needed is desirable. They said: "Knowledge acquired of what a worker must know and what he must be able to do, supplemented by advice from occupational advisory groups, will provide the raw materials and ingredients for the several courses that will make up the occupational skill and knowledge development program."[2]

Schill and Arnold recognize the need for further research in their summary:

> A cursory examination of the curricula in various institutions designed to prepare technicians must result in the conclusion that the training programs for any specific technology have little similarity. Now that research has been completed on the basic terms, occupational groupings, and areas of manpower needs, it is time to identify more precisely the curricula content common to a variety of technical training programs.[3]

Purpose and Objectives

The purpose of this study is to identify clusters of knowledge and specific knowledges most widely utilized in major types of work commonly done by electronic technicians. This purpose is derived from observations and inquiries indicating that such information is needed by (1) community colleges and technical schools providing instruction for electronic technicians and (2) high schools offering pre-vocational education serving as a basis for continued study in community colleges or technical schools.

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[1]Lloyd J. Phipps and Gerald R. Fuller, Technical Education in and for Rural Areas: Technicians and Other Workers Who Need Technical Knowledge. Vocational and Technical Education Department, University of Illinois, Urbana, 1964, p. 57.

[2]John P. Walsh and William Selden, "Vocational Education in the Secondary Schoo," Vocational Education, ed. Melvin Barlow, Part I, Sixty-fourth N.S.E.E. Yearbook (Chicago: University of Chicago Press, 1965), p. 91.

[3]William J. Schill and Joseph P. Arnold, Curricula Content for Six Technologies, College of Education, University of Illinois, Urbana, 1965, p. 92.

METHOD

Method is based on reasoning as follows: Educators planning instructional programs need accurate information about knowledges and competencies for preparation of electronic technicians. Knowledges and competencies associated with performance of the principal tasks constituting major portions of technicians' work are most likely to be most essential. Therefore, principal tasks should be conceptualized, and information about the extent to which workers perform each task should be obtained. Then knowledges associated with performance of principal tasks should be identified. Knowledges common to performance of two or more principal tasks, and those associated only with performance of specific tasks, should be identified. Such information will provide a partial basis for planning both basic and specialized courses.

Definitions of Principal Tasks

Definitions of principal tasks were derived mainly from the work of Emerson,[1] and Phipps,[2] and from discussions with technicians and their employers. Analysis indicated that electronic technicians' major tasks can be classified into eight categories as follows: diagnosing trouble in systems; adjusting and/or operating; servicing; assembling; installing; designing and computation; application, distribution, and sales; and quality control and testing.

Definitions of those concepts of principal tasks follow.

Diagnosing Trouble in Systems: This work definition refers to tasks involving measurements and decisions leading to replacement of, or repairs to, units in electronic systems or devices. While the worker may routinely make adjustments and repairs, his principal tasks are associated with diagnosing failures or malfunctions of units of a system, the isolation of the trouble, and replacement or repair of components within a system.

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[1]Emerson, Lynn A., Education for a Changing World of Work, Appendix I. Report of the Panel of Consultants on Vocational Education, U. S. Department of Health, Education, and Welfare, Office of Education, OE-80022, Washington: Government Printing Office, 1963.

[2]Phipps, Lloyd J., and Gerald Fuller, Technical Education in and for Rural Areas: Technicians and Other Workers Who Need Technical Knowledge, Vocational and Technical Education Department, University of Illinois, Urbana, 1964.

Adjusting and/or Operating: This definition refers to tasks principally involved in routine operation of electronic equipment. While the identification of malfunctions of equipment and minor component replacements may be a portion of such a worker's responsibility, his main function is one of performing tasks related to operation.

Servicing: This definition refers to those tasks principally involved in replacement of components constituting electronic assemblies. While considerable diagnostic work is associated with this task, the actual part-for-part replacement more precisely describes the nature of the work.

Assembling: This definition refers to those tasks principally related to production of electronic assemblies, subassemblies, parts, and similar assembling.

Installing: This definition refers to tasks principally devoted to installing electronic assemblies, and to associated interconnections. Testing and adjusting portions of assemblies to assure proper operation as part of the installing process are elements of this task.

Designing and Computation: This definition refers to tasks principally involved in application of scientific and electronic principles to design of electronic devices. Workers performing such tasks may routinely assemble prototypes, measure and adjust performance of devices, make necessary calculations, and perform functions related to specification development for electronic devices. Such workers may also perform some drafting functions.

Application, Distribution, and Electronic Sales: This definition refers to tasks principally associated with applications of developed devices, components, and services, and those associated with sales and distribution of electronic devices.

Quality Control and Testing: This definition refers to tasks principally involved in measurements and adjustments of electronic devices to verify operating tolerances and specifications and to make minor modifications necessary for proper performance.

The validity of these categories was verified by conducting informal discussions with management representatives and employees of establishments engaged in a wide range of electronics work. Firms studied represent aerospace, electronic controls, communications, industrial applications, defense installations, and service industries. Management representatives interviewed included owners, planning managers, personnel managers, engineers, and directors of maintenance. The representatives were asked: "Do the descriptions accurately describe the principal tasks performed by the technicians employed in your establishment?" In all cases,

management representatives classified technicians as performing the principal tasks with little or no difficulty. The slight difficulties that did occur appeared to be due to the fact that a task was not performed or was performed infrequently in a particular establishment.

The Knowledge Questionnaire Used for Data Collection

A questionnaire check list was designed to enable employed technicians to identify knowledges necessary for performance of their principal tasks. Knowledges were identified by review of textbooks, courses of study, the suggested curriculum guide prepared by the United States Office of Education,[1] instructors, and technicians themselves. Six hundred and thirty-seven knowledge items so identified were utilized to construct a preliminary list.

To facilitate analysis of responses, check list items were then arranged in seven major categories: (1) basic electronic concepts, (2) components, (3) electronic measurements, (4) simple electronic circuits, (5) electronic systems, (6) waves and wave propogation, and (7) construction and related knowledges. In each category, items were listed in orders descending from general to the more specific. General items signified broad areas of knowledge. Under each general item more detailed ones were listed. Respondents were instructed to omit response to detailed items under a general head if the general knowledge was not needed in their work. These lists were submitted to a jury of three electronics professors to check the relevance of items. On the basis of those critiques, the check list was revised and reviewed by technicians employed at Washington State University to determine if wording of items was clear. By this method, a first version of the instrument was completed.

The instrument was then pre-tested by electronics technology instructors in three community colleges. Sixty-seven students completing the second or third year of electronics study participated in the pre-test. Instructors made notes about questions asked by students. Those notes were utilized as bases for final revision of the instrument. All items not deemed important by at least four per cent of the students were eliminated. Three knowledges recently introduced and not included in current texts were added.

The final version of the instrument is reproduced in Appendix A.

Sources of Data

Definition of Population: An objective of the study was to sample a population representative of the major tasks performed by electronic technicians

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[1] Office of Education, Electronic Technology, A Suggested 2-Year Post High School Curriculum, U.S. Department of Health, Education, and Welfare, OE-80009 (Washington, D.C.: Government Printing Office, 1960).

in the United States. An examination of the kinds, establishments, and numbers of workers in Washington State reported by the Employment Security Agency indicated that manufacturing, operation, communications, marine and mobile installations, and aircraft-aero-space industries are located in the Puget Sound area of Washington State.[1] A further definition of the population was possible by restricting the classification of industries represented to certain classification of the Standard Industrial Classification numbers.[2] Those Classification numbers and descriptions are:

3571 Manufacture of computing machines, accounting machines, including electronic and cash registers

3611 Electric measuring instruments and test equipment

3622 Industrial controls

3662 Radio and television transmitting, signaling, and detecting equipment and apparatus

4830 Television and radio broadcasting

5065 Radio and television stores

7622 Radio repair shops, television repair shops

Analysis of employment available to electronics workers represented in this population indicated that the above classifications excluded significant numbers of technicians employed by the Federal Government to maintain and modernize electronic systems. Consequently, the population was extended to include technicians employed to maintain and modernize governmentally owned electronic installations.

Identification of the Population: A listing of 549 firms, establishments, and agencies in the Puget Sound area was obtained. To determine the numbers of employed technicians to be queried in representative installations, facts about the nature of work performed by technicians and numbers employed were obtained by personal interviews with employers. By this method, an estimate of the number of technicians performing each of the principal tasks was obtained. A composite list of each group of technicians performing each principal task was prepared for sampling.

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[1]Sidney E. Smith, Commissioner, Employment and Payrolls in Washington State by County and by Industry, No. 74, First Quarter, 1965, Research and Statistics Section, Employment Security Department, State of Washington, October 8, 1965.

[2]Technical Committee on Industrial Classification, Standard Industrial Classification Manual, Bureau of the Budget, Executive Office of the President, (Washington, D.C.: U.S. Government Printing Office, 1957).

Sampling: The population identified consisted of unequal numbers of electronic technicians performing the defined principal tasks. A random sample, drawn from the population as a whole, would not include large enough numbers of technicians performing principal tasks unless the total sample was large. Methods were sought and adopted to divide the total population into sub-populations performing each principal task and to sample each sub-population separately. A method of variable sampling developed by the Research Division of the National Education Association was used.[1] The process consists of determining, by a planned process, a homogeneous sub-population and of sampling in such a fashion as to include as many of the characteristics of the sub-population as possible. This method utilizes heterogeneous sampling within the homogeneous sub-population.

A sample of 20 technicians performing each principal task was selected. This sample size was chosen to allow as much choice as possible in the selection of technicians from the smaller sub-populations.

The samples were taken from the lists of electronics technicians prepared during the assessment of the population. The numbers of technicians to be questioned in each establishment were determined by use of a table of random numbers. Each individual performing a principal task was assigned a number; and the numbers 25 to 33 were drawn, the larger samples being drawn from the groups including greater numbers of technicians performing principal tasks.

When the respondents were so selected, management representatives personally explained the purpose of the study and requested their cooperation.

One hundred and fifty-four (154) usable questionnaires were returned.

Analysis of Population and Sample: Table 1 shows the total number of technicians performing each principal task, the proportion of this sub-population sampled, and the number and per cent of questionnaire returned.

The numbers of technicians employed in establishments employing one to nine and in those employing ten or more, and the numbers performing principal tasks was tabulated. Those facts are shown in Table 2.

The data obtained from employers were examined to determine the products or services resulting from tasks performed by technicians. Individual manufacturers, the industrial classification, the number of technicians sampled, and the number and per cent return is shown in Table 3. A similar analysis of technicians employed by non-manufacturing establishments grouped by services is contained in Table 4.

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[1] Research Division of the National Education Association, Sampling and Statistics Handbook for Surveys in Education, (Washington: National Education Association, 1965, Mimeograph).

TABLE 1

TASK ASSIGNMENTS OF POPULATION

Task Number	Technicians Employed	Technicians Sampled	Percentage Subpopulation Sampled	Questionnaires Returned	Percentage Returned
1	99	33	30.0	25	83.3
2	170	31	18.3	24	77.5
3	381	28	7.4	20	71.5
4	54	27	50.0	20	74.1
5	36	26	72.3	19	73.1
6	57	25	43.9	19	76.0
7	68	27	39.7	17	62.9
8	85	25	29.4	20	80.0

TABLE 2

ESTABLISHMENT SIZE BY TASKS PERFORMED

	Establishments	No. of Technicians by Task Number							
		1	2	3	4	5	6	7	8
Population	Establishments employing:								
	10 or more technicians	89	104	12	39	9	53	24	80
	1 - 9 technicians	10	66	369	15	27	4	44	5
	Total	99	170	381	54	36	57	68	85
Sample	Establishments employing:								
	10 or more technicians	26	15	7	15	8	22	4	22
	1 - 9 technicians	7	16	21	12	18	3	23	3
	Total	33	31	28	27	26	25	27	25
Returned	Establishments employing:								
	10 or more technicians	18	11	7	7	7	16	2	17
	1 - 9 technicians	7	13	13	13	12	3	15	3
	Total	25	24	20	20	19	19	17	20

TABLE 3

PRODUCTS PRODUCED BY MANUFACTURERS

Standard Industrial Code	Products	Number Sampled	Returned	
			No.	%
3611	Precision instruments	3	0	0
3622	Industrial controls	2	2	100
3622	Power controllers	2	2	100
3622	Sonar systems, controls	13	11	85
3662	Radio telephones	3	3	100
3662	Aircraft and portable radio systems	5	5	100
3662	Depth finders, ultrasonics	2	2	100
3662	Aerospace control systems	19	16	84
3679	Electronic instrumentation	5	5	100
5065	Strain gauges, power supplies	3	3	100
5065	Telephone test sets, heat controls	2	2	100
3571	Data transmission, processing	5	0	0
3571	ntrols, analog computers	4	4	100
3611	Precision measuring instruments	19	9	45
5065	Power supplies, intercoms	7	3	43
5065	Telephone test sets, power supplies	1	1	100
5065	Medical electronic devices	2	2	100
	Totals	97	70	72.2

TABLE 4

TYPES AND NUMBERS OF NONMANUFACTURING FIRMS

Specialization	No. of Establistments	No. of Technicians	No. Sampled	Returned	
				No.	%
Radio and television stations	25	170	31	24	77.5
Electronic installers, two-way radio, other installers	7	27	15	11	73.3
Wholesale distributors and manufacturer's representatives	6	60	25	15	56.0
Electronic servicing, maintenance	92	360	49	39	81.3
Electronic research	1	37	5	5	100.0
Totals	113	654	125	94	75.8

Analysis of Data

The data from the returned questionnaires was coded and punched on data processing cards for analysis. A computer program based on a modification of "cross classification with subdivision" method[1] and the programming language Fortran II on the International Business Machines 709 computer was utilized to process data.

A master table listing all responses of the technicians performing each principal task was prepared. From this data Appendices B and C were prepared. Appendix B, pages 51-53, lists knowledge items that 90 per cent of the respondents deemed necessary for performance of principal tasks. Appendix C, pages 54-59, lists items deemed to be essential by 60-89 per cent of the respondents. Table 5, derived from those lists, shows knowledges associated with performance of six or more principal tasks. Table 6 shows those associated with three to five tasks.

Interpretation

As previously noted, the knowledge check list was designed to facilitate analysis of responses in frameworks of seven major categories: (1) basic electronic concepts, (2) components, (3) electronic measurements, (4) simple electronic circuits, (5) electronic systems, (6) waves and wave propogation, and (7) construction and miscellaneous related knowledges.

Analysis of data presented on Tables 5, 6, 7, and 8 shows that the knowledges reported to be needed by technicians performing different principal tasks was greatest for general knowledge items. Extent of usefulness tends to decrease as knowledge items became more specific. (Descriptive and non-mathematical items are widely useful. The importance of mathematical competence is discernible from this decreasing agreement. Differences between knowledges perceived to be useful by individual technicians performing various principal tasks appear to be partly due to differences in the complexity of knowledge involved.)

This study was undertaken to identify those knowledges which were needed by technicians in performing principal tasks. Data indicate that there are a substantial number of common elements in instructional programs necessary to prepare technicians for widely performed types of tasks and for tasks performed by relatively few specialists.

Basic Electronic Concepts: All technicians report need for knowledge of electronic definitions and (units.) Similarly, most technicians report need for knowledge of combinations of circuit elements such as resistors in series and parallel. Only those technicians performing Principal Task 6, however, report need of knowledge of mesh and nodal analysis. All technicians expressed

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[1] Ronald Anderson, Cross Classification with Subdivision, Institute for Sociological Research, University of Washington, Seattle, Washington, 1964, (Mimeographed).

TABLE 5

KNOWLEDGE ITEMS NECESSARY FOR PERFORMANCE OF SIX OR MORE PRINCIPAL TASKS

Item Number See Check List, pages 33 - 50 for names of items denoted by numbers	Knowledge	Principal Tasks 1	2	3	4	5	6	7	8
		Diagnosing trouble	Adjusting and/or operating	Servicing	Assembling	Installing	Designing and computation	Application, distribution and sales	Quality control and testing
1	Basic electronic knowledges	x	x	x	x	x	x	x	
2	Units and definitions	x	x	x	x	x	x	x	x
3	Volts, amperes, watts, prefixes	x	x	x	x	x	x	x	x
4	Resistance of conductors	x	x	x	x	x	x		x
5	Temperature effects on resistors, conductors	x	x	x		x	x		x
6	Conductance	x	x	x		x	x		x
7	Power in resistors	x	x	x	x	x	x		x
8	Circuit and netword laws	x	x	x	x	x	x		x
9	Ohm's law	x	x	x	x	x	x		x
10	Resistors in series and parallel	x	x	x	x	x	x		x
13	Electrical symbols	x	x	x	x	x	x		x
15	Component symbols for electronics	x	x	x	x	x	x		x
17	Capacitances; currents and voltages	x	x	x		x	x		x
25	Capacitors in series and parallel	x	x	x	x	x	x		x
26	Inductances; currents and voltages	x	x	x		x	x		x
80	Individual components	x	x	x	x	x	x	x	x
81	Capacitors	x	x	x	x	x	x	x	x
82	Ratings of capacitors	x	x	x	x	x	x	x	x
83	Capacitor color codes	x	x	x	x	x	x	x	x
84	Tolerances of capacitors	x	x	x	x	x	x	x	x

TABLE 5 CONT.

Item	Knowledge	Principal Tasks							
		1	2	3	4	5	6	7	8
85	Types of capacitors	x	x	x	x	x	x	x	x
88	Symptoms of failure of capacitors	x	x	x		x	x		x
101	Transformers	x	x	x		x	x		x
102	Power transformers for electronics	x	x	x		x	x		x
103	Ratings of transformers	x	x	x		x	x		x
104	Symptoms of failure of transformers	x	x	x		x	x		x
110	Output transformers	x	x	x		x	x		x
116	Chokes	x	x	x		x	x	x	x
117	Choke types	x	x	x		x	x		x
118	Filter chokes	x	x	x		x	x		x
130	Rectifying devices	x	x	x	x	x	x	x	x
131	Solid state diodes	x	x	x	x	x	x	x	x
132	Ratings of diodes	x	x	x	x		x	x	x
133	Signal rectifiers	x	x	x	x		x	x	x
134	Zener diodes	x	x	x	x		x	x	x
135	Power rectifiers, solid state	x	x	x			x	x	x
137	Diode markings and codes	x	x	x	x	x	x	x	x
138	Failure of diodes	x	x	x	x	x	x		x
152	Semi-conductors	x	x		x	x	x		x
221	Electro-mechanical devices	x	x	x	x		x		x
222	Relays	x	x	x	x	x	x		x
223	Direct current relays	x	x		x	x	x		x
232	Switches	x	x		x	x	x		x
264	Fuses	x	x	x	x	x	x	x	x
265	Types of fuses	x	x	x		x	x	x	x
266	Characteristics of fuses, time, current	x	x	x		x	x		x
267	Fuse limits	x	x	x		x	x		x
269	Measurement techniques and devices	x	x	x	x	x	x		x
270	Voltage measurements	x	x	x	x	x	x		x
271	Low impedance voltage measurements	x	x	x	x	x	x		x
272	High impedance voltage measurements	x	x	x	x	x	x		x
275	Measurement of very low voltages	x	x		x	x	x		x
276	Radio frequency voltage measurements	x	x	x		x	x		x
277	Audio voltage measurements	x	x	x	x	x	x		x
279	Current measurements	x	x	x	x	x	x		x

TABLE 5 CONT.

Item	Knowledge	Principal Tasks							
		1	2	3	4	5	6	7	8
280	Direct current measurements	x	x	x	x	x	x		x
281	Alternating current measurements	x	x	x		x	x		x
294	Types and uses of measuring instruments	x	x	x	x	x	x		x
295	Use of volt-milliammeter	x	x	x	x	x	x		x
296	Applications of volt-milliammeter	x	x	x	x	x	x		x
297	Limits of accuracy of volt-milliammeter	x	x	x	x	x	x		x
298	Vacuum tube voltmeter	x	x	x	x	x	x		x
299	Applications of vacuum tube voltmeter	x	x	x	x	x	x		x
300	Accuracy of vacuum tube voltmeters	x	x	x	x	x	x		x
301	Symptoms of failure of vacuum tube voltmeters	x	x	x	x	x	x		
302	Use of oscilloscopes	x	x	x	x	x	x		x
303	Use of single trace of oscilloscopes	x	x	x	x	x	x		x
304	Principles of use of oscilloscopes	x	x	x	x	x	x		x
305	Limitations of oscilloscopes	x	x	x	x		x		x
306	Frequency measures by oscilloscope	x	x	x	x		x		x
311	Amplitude measures by oscilloscope	x	x	x	x		x		x
339	Uses and types of signal generators	x	x	x		x	x		x
340	Radio frequency signal generators	x	x	x		x	x		x
341	Audio frequency signal generators	x	x	x		x	x		x
359	One or two active element circuits, applications	x	x	x	x	x	x		x
360	General circuit applications of amplifiers	x	x	x	x	x	x		
370	Transistor amplifiers	x	x	x	x	x	x		x
371	Operating levels of transistor amplifiers	x	x	x	x	x	x		x
444	Power supplies	x	x	x	x	x	x		x
445	Rectifier circuit types	x	x	x		x	x		x
446	One-half wave rectifiers	x	x	x		x	x		x
447	Full wave rectifiers	x	x	x	x	x	x		x
456	Filter methods	x	x	x		x	x		x
589	Resistor color code	x	x	x	x		x		x

TABLE 6

KNOWLEDGE ITEMS NECESSARY FOR PERFORMANCE OF THREE TO FIVE PRINCIPAL TASKS

Item Number See Check List, pages 33 - 50 for names of items denoted by numbers	Knowledge	Principal Tasks							
		1 Diagnosing trouble	2 Adjusting and/or operating	3 Servicing	4 Assembling	5 Installing	6 Designing and computation	7 Application, distribution and sales	8 Quality control and testing
14	Power component symbols	x	x						x
16	Time varying current circuits	x	x			x	x		
18	Capacitance of plates, wires	x	x				x		
19	Charge on capacitors	x	x				x		x
20	Capacitive reactance	x	x				x		x
21	Calculation of capacitive reactance		x				x		x
22	Phase and impedance of resistance-capacitance	x	x				x		x
23	Current lead in resistance-capacitance circuits	x	x				x		x
24	Time constants of resistance-capacitance	x	x				x		x
27	Self-inductance of wires and coils	x	x				x		x
28	Inductance in series and parallel	x	x	x			x		x
29	Mutual inductance, coupling		x				x		x
30	Time constant of resistance-inductance circuits	x	x				x		x
31	Reactance of inductors	x	x		x		x		x
32	Impedance of resistance-inductance networks	x	x				x		x

TABLE 6 CONT.

Item	Knowledge	Principal Tasks							
		1	2	3	4	5	6	7	8
33	Current lag in resistance-inductance circuits		x				x		x
34	Q of coils	x	x				x		
35	Impedance in alternating current circuits	x	x				x		x
36	Tuned circuits	x	x				x		x
37	Impedance, currents, voltages in tuned circuits	x	x				x		
42	Special reactive networks	x	x				x		x
44	L, Pi, and T networks, impedance changes	x	x				x		
45	Signal frequency filter networks	x	x	x			x		x
46	Alternating current circuit theory	x	x				x		x
48	Addition and subtraction of vectors	x	x				x		
52	Wye and delta circuits	x	x			x			
55	Current generation principles	x	x				x		x
61	Electromagnetism, magnetism	x	x						x
71	Transients, special wave shapes	x	x				x		x
72	Characteristics of non-sine waves	x	x				x		x
73	Harmonics generated in non-sine waves	x	x				x		x
74	Wave analysis	x	x				x		x
75	Square waves	x	x				x		x
76	Pulses	x	x				x		x
77	Sawtooth waves	x	x				x		x
78	Wave shaping	x	x				x		x
86	Capacitor dielectrics	x	x				x		x
89	Signal frequency inductors	x	x				x		x
90	Inductor types and specifications		x				x		x
95	Core effects in inductors		x				x		x
98	Inductance formulas and calculations		x				x		x
105	Transformer color coding		x	x		x	x		
106	Electronic transformers	x	x			x	x		x
107	Input transformers	x	x			x	x		x
108	Impedance transformation by transformers		x			x	x		
113	Impedance matching using output transformers		x			x	x		
115	Color codes of output transformers		x	x		x			
122	Ratings of filter chokes		x	x			x		
123	Radio frequency chokes	x	x	x		x	x		
127	Audio frequency chokes		x	x		x			

TABLE 6 CONT.

Item	Knowledge	Principal Tasks							
		1	2	3	4	5	6	7	8
136	Load characteristics of solid state rectifiers		x	x			x		x
139	Vacuum diodes	x	x	x		x		x	
140	Ratings and types of vacuum diodes	x	x	x		x		x	
142	Failure symptoms of vacuum diodes	x	x	x		x			
153	Semi-conductor characteristics	x	x				x		x
155a	Field effect transistor operation		x				x		x
155b	Silicon controller rectifier operation		x				x		x
155c	Unijunction devices		x				x		x
158	Bias requirements of transistors		x				x		x
159	Receiving tubes	x	x	x		x		x	
160	Triode tube characteristics	x	x	x		x			
161	Internal construction of vacuum tubes		x	x		x			
163	Characteristics of tetrodes and pentodes	x	x	x		x			
164	Applications of pentodes and tetrodes		x	x		x			
165	Characteristics of multi-grid vacuum tubes	x	x	x		x			
166	Cathode ray and display tubes	x	x	x			x		
170	Electron beam deflection methods	x	x	x					
178	Electro-mechanical devices, transducers	x	x						x
197	Speakers and other reproducers		x	x		x			
201	Frequency characteristics of cone speakers	x	x	x					
211	Maintaining frequency		x			x	x		
224	Coil resistance of relays	x	x				x		x
225	Relay contact capabilities and limits	x	x				x		x
226	Current, voltage requirements, speed of relays	x	x				x		x
228	Alternating current relays	x	x				x		x
233	Signal and power switch types	x	x				x		x
236	Specifications and uses of multi-contact switches		x		x		x		x
237	Current and voltage capabilities of switch types	x	x				x		x
238	Switch insulation and isolation	x	x				x		x
257	Vibrators		x	x				x	

TABLE 6 CONT.

Item	Knowledge	Principal Tasks							
		1	2	3	4	5	6	7	8
268	Replacement standards of fuses	x	x	x		x			x
273	Measurement of special voltages	x	x			x	x		x
274	High voltage measurements	x	x	x			x		x
278	Decibel signal measurements	x		x		x	x		x
282	Measurement of special wave shape currents		x				x		x
284	Measurement of very small currents	x					x		x
288	Principles of power measurement	x	x			x	x		
293	Power measurements in decibels		x			x	x		
307	Oscilloscope measurement of pulses, phase, time	x	x		x		x		x
308	Direct current measurements by oscilloscope	x	x				x		x
309	High frequency oscilloscope measurements	x	x		x		x		x
310	Triggering, control methods for oscilloscopes	x	x		x		x		x
312	Dual trace oscilloscopes	x	x		x		x		x
313	Phase, time measures on dual trace oscilloscopes	x	x				x		x
314	Gain, wave shape on dual trace oscilloscope	x	x				x		x
315	Moderate accuracy measuring equipment	x	x				x		x
316	Resistance, inductance, capacitance checkers		x				x		x
320	Operation of tube checkers		x	x		x			
325	Use of precision measuring equipment		x				x		x
342	Operation of pulse generators	x	x				x		x
343	Operation and uses of sweep generators	x	x	x					
361	Operating conditions of amplifiers	x	x	x		x	x		
372	Transistor biasing calculations		x	x			x		x
374	Transistor amplifier voltage and current gain		x	x	x		x		x
375	Transistor frequency limits		x				x		x

TABLE 6 CONT.

Item	Knowledge	Principal Tasks							
		1	2	3	4	5	6	7	8
377	Common emitter, base, collector circuits		x	x			x		x
378	Transistor coupling methods		x	x		x	x		
380	Tuned amplifiers	x	x	x		x	x		
381	Single tuned amplifiers		x	x		x			
386	Very high frequency circuits		x	x		x			
399	Direct coupled amplifiers	x	x				x		
402	Modulation, detection, mixing principles	x	x				x		
403	Detectors	x	x	x					
428	Oscillator operating principles	x	x	x			x		
429	Oscillator types	x	x	x			x		
435	Multivibrator circuits	x	x	x					
437	Oscillator stabilization	x	x	x			x		
438	Wave shaping circuitry, counters	x	x				x		x
440	Clipping, biasing diodes for wave shaping	x	x				x		
448	High voltage rectifiers	x	x	x					
457	Filter effects on power supply regulation	x	x			x	x		
458	Condenser input filters	x	x	x		x	x		
459	Choke input filters	x	x	x		x	x		
460	Bleeders for power supplies		x	x			x		
461	Principles of rectifier controls	x	x				x		
462	Methods and circuits for voltage control	x	x				x		x
463	Methods and circuits for current control	x	x				x		x
466	Transistor power supplies	x	x	x					x
468	Operation of electronic systems	x	x			x	x		
469	Amplifier systems operation	x	x	x		x			x
470	Operation of audio amplifier units	x	x	x		x			
472	Fixed tuned intermediate frequency amplifier units	x	x	x					
474	Direct coupled amplifier systems	x	x				x		
555	Antenna types and selection		x	x		x			

TABLE 6 CONT.

Item	Knowledge	Principal Tasks							
		1	2	3	4	5	6	7	8
557	Dipole antennas		x	x		x			
558	Folded dipole antennas		x	x		x			
559	Broad-band antennas		x	x		x			
560	Multi-element and parasitic element antennas		x	x		x			
578	Electronic construction procedures		x		x		x		
579	Tools, materials, methods of construction		x		x		x		x
580	Chassis, cabinet, and panel preparation		x		x		x		
581	Drill sizes		x		x		x		
582	Tap sizes and tapping in construction		x		x		x		
583	Hole punches, saws, and nibblers		x		x		x		
587	Stamping, marking, screening, labeling panels		x		x		x		
588	Wiring and cabling	x	x		x	x	x		
590	Condenser color codes		x	x	x		x		
591	Transformer and choke color codes		x	x	x		x		
592	Conductor identification in cables, wire codes		x		x		x		
593	Printed circuit boards			x	x		x		
594	Assembly methods for printed circuit boards		x		x		x		
595	Parts assembly on printed circuit boards		x		x		x		
599	Electronic drafting, illustrating		x		x		x		
611	Principles of noise reduction		x		x	x	x		

need of knowledges of tuned circuits in moderate detail. Grouping of students for instruction in basic concepts, definitions, and elementary theory appears feasible.

Workers performing adjusting and/or operating, diagnostic, servicing, and quality control tasks report need for various combinations of inductance and capacitance knowledges as they apply to alternating currents. These same groups report need for special knowledges relating to transients and special wave shapes. Technicians trained for performance of those tasks need special training in the more theoretical aspects of time-varying currents and voltages.

Components of Electronics: All technicians report agreement on need for detailed knowledges of capacitors, transformers, solid state rectifiers, and fuses. Need for a general knowledge of transistors, vacuum tubes, and relays is also reported needed by all. Those performing adjusting, operating, design, computation, quality control, and testing tasks report need of detailed knowledges of inductors, transistors, relays, and switches. Performance of Principal Task 2 is associated with more detailed knowledge of gas-filled tubes, mercury vapor rectifiers, transmitting tubes, motors, generators, and frequency controlling crystals. Technicians performing adjusting and operating tasks indicate need for knowledge of sound reporducing devices. Those performing installation tasks emphasize need for knowledge of microphones. Knowledge of techniques of impedance matching are reported needed by technicians performing adjusting, operating, installation, design, and computation tasks.

The greater need for more mathematically related knowledges is again exhibited by technicians performing diagnostic, adjustment, operational, design, computation, quality control, and testing tasks.

General knowledge of all components is required by all technicians. Accordingly, students being prepared for performance of those tasks may be grouped for much mathematics and components instruction.

Electronic Measurements: All technicians except those performing task distribution and sales tasks expressed a need for knowledge of alternating and direct voltage and current measurements. All reported frequent use of volt-ohm-milliammeters, the vacuum tube voltmeters, and single trace oscilloscopes. Those performing diagnostic, adjustment, operational, assembling, design, computation, quality control, and testing tasks indicate need for knowledges of advanced models of oscilloscopes utilizing triggering circuits and dual beams. Knowledge essential for use of moderate accuracy equipment was reported to be needed by technicians performing adjustment, operational, diagnostic, computation, quality control, and testing tasks. Knowledge of transistor characteristics, display equipment and choices of transistors were reported needed by those engaged in design, computation, quality control, and testing tasks. Those performing design and computation tasks expressed need for knowledge of low frequency parameters of transistors. Need for knowledges of pulse generating equipment was indicated by technicians

performing diagnostic, adjustment, operational, design, computation, quality control, and testing tasks. Knowledge of common signal sources was reported to be necessary by all technicians except those performing assembling and sales tasks. Knowledge of distortion analyzers are reported needed by technicians performing diagnostic, design, and computation tasks.

Table 5 includes names of electronic instruments with which all technicians need familiarity. The substantial importance of the oscilloscope should be noted.

Simple Electronic Circuits: All technicians except those performing distribution and sales tasks report need for general knowledges of applications of electronics principles to amplifiers and rectifier circuits. Knowledge of Filter circuits was needed by technicians performing diagnostic, adjustment, operational, installation, servicing, design, and quality control tasks. Knowledge of principles of detection, modulation, and mixing were reported to be needed by technicians performing adjustment, operational, and service tasks. Those performing diagnostic, adjustment, and operational tasks reported need for knowledge of methods and circuits of wave shaping. Those performing adjustment and operational tasks signified need for detailed knowledge of rectifier circuits. Those performing diagnostic, adjusting, operational, and servicing tasks also need knowledge of high voltage rectifiers.

Sufficient commonality of need exists for grouping students studying electronic circuits. Emphasis on certain types of circuits are indicated for the preparation of workers for performance of specific principal tasks.

Electronic Systems: All technicians reported some need for knowledge of electronic systems, but most agreement was reported by those working on amplifier systems, particularly audio systems. Only workers performing adjustment and operational tasks reported need for extensive knowledge of transmitters, speech, and video systems. Those engaged in servicing work indicated need for knowledges of receiving systems.

(Schools need provide little electronic systems instruction except for technicians preparing to perform adjustment and operational tasks.)

Waves and Wave Propogation: Knowledges of waves and wave propogation were reported necessary by technicians engaged in adjustment, operational, service, and installation work. Those engaged in adjustment and operational tasks reported need for detailed knowledges of waves. Those performing Principal Task 3 reported need for knowledges of reception of very high and ultra-high frequency waves. Knowledges of lines, matching methods, and antennas were reported necessary by technicians performing adjustment, operational, and installation tasks.

Study of wave transmission and wave propogation is necessary mainly for preparation to perform adjustment, operational, servicing, and installation tasks. The training program for all technicians needs to include

knowledges of waves at an elementary level as indicated by the responses of the sampled technicians.

Construction and Miscellaneous Knowledges: Technicians performing adjustment, operational, assembling, design, and computation tasks need knowledge of mechanical and electrical construction, drafting and graphic display. Knowledge of noise-reducing procedures for installation of portable or mobile systems is essential for those engaged in adjustment, operational, assembling, installation, design, and computation tasks. (Knowledges required to obtain a first- or second-class radio-telephone license issued by the Federal Communications Commission are required for technicians performing adjustment, operational, and installation tasks.)

DISCUSSION

A major finding of this study is that 84 of the 637 knowledges identified as useful in some phase of electronic technicians' work are deemed essential for six of the eight principle tasks they perform.

Those knowledges are commonly useful in major parts of the work all electronic technicians do. They represent competencies that contribute to work in a variety of entry jobs and those that provide a partial basis for more advanced training. For both reasons acquisition of those knowledges can be presumed to increase a student's occupational adaptability and mobility.

Consequently, it can be assumed that the 84 most commonly useful knowledges listed on Table 5 constitute basic elements of content for introductory electronic courses.

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the above facts and assumptions, it can be concluded that schools and community colleges can productively focus energy on development of introductory courses designed to help pupils acquire the 84 widely useful knowledges listed on Table 5. Instructors planning more advanced courses offered by technical schools, community colleges, or adult programs can reasonably consider means of enabling students to acquire the additional knowledges listed on Table 6.

Obviously, particular schools, community colleges, and industries will need to outline content for other instructional programs designed to prepare electronic technicians for specialized types of work.

As rapidly as possible, colleges, universities, Regional Laboratories, and other research agencies should proceed with development and experimental use of instructional materials designed to help students acquire the knowledges listed on Tables 5 and 6. In cooperation with the Northwest Regional Educational Research Laboratory, the staff of Project ERD-257-65 plans to develop and test instructional systems designed to fulfill part of that need. Implementation of those plans is contingent of approval of necessary funds.

SUMMARY

The objective of this study was to identify specific knowledges and clusters of knowledges most widely useful in major types of work commonly done by electronic technicians.

Principal tasks were defined as those most commonly performed by electronic technicians in industries in which major percentages of such workers are employed. Electronic technicians' work was divided into eight principal tasks as follows: diagnosing trouble in systems; adjusting and/or operating; servicing; assembling; installing; designing and computing; application, distribution, and sales in electronics; and quality control and testing.

A questionnaire permitting technicians to identify knowledges needed in performance of their work was utilized to obtain data. A population of electronic technicians was defined as those technicians employed in 64 establishments within certain industrial classifications. Employees of these establishments perform tasks broadly representative of the national pattern of electronics work. The number and percentage of technicians performing each principal task was determined. A stratified sampling was identified by use of disproportional sample sizes. Samples were drawn from electronic manufacturing, broadcasting, servicing, general maintaining, and research establishments. The data was provided by 154 usable questionnaires.

Knowledge items were defined as necessary for performance of a principal task if 60 per cent of the respondents indicated them to be needed in their work. Six hundred forty-three knowledge items were investigated, resulting in identification of knowledges necessary for the performance of six to eight tasks, three to five tasks, and one or two tasks.

Eighty-four of the 643 knowledges were found to be associated with the performance of six or more of the eight tasks. One hundred fifty-four knowledges were found to be associated with three to five tasks.

Knowledges reported to be necessary for performing tasks are grouped to assist schools in planning training for electronics technicians. Knowledges specific to smaller groups of principal tasks were identified and similarly grouped.

APPENDIX A

THE KNOWLEDGE SURVEY CHECK LIST

INSTRUCTIONS: Choose and check (✓) the task description that most nearly describes the type of work you do.

☐ DIAGNOSING TROUBLE IN SYSTEMS: This work definition refers to tasks involving measurements and decisions leading to replacement of, or repairs to, units in electronic systems or devices. While the worker may routinely make adjustments and repairs, his principal tasks are associated with diagnosing failures or malfunctions of units of a system, the isolation of the trouble, and replacement or repair of components within a system.

☐ ADJUSTING AND/OR OPERATING: This definition refers to tasks principally involved in routine operation of electronic equipment. While the identification of malfunctions of equipment and minor component replacements may be a portion of such a worker's responsibility, his main function is one of performing tasks related to operation.

☐ SERVICING: This definition refers to those tasks principally involved *in replacement of components constituting electronic assemblies. While* considerable diagnostic work is associated with this task, the actual part-for-part replacement more precisely describes the nature of the work.

☐ ASSEMBLING: This definition refers to those tasks principally related to production of electronic assemblies, subassemblies, parts, and similar assembling.

☐ INSTALLING: This definition refers to tasks principally devoted to installing electronic assemblies and to associated interconnections. Testing and adjusting portions of assemblies to assure proper operation as part of the installing process are elements of this task.

☐ DESIGNING AND COMPUTATION: This definition refers to tasks principally involved in application of scientific and electronic principles to design of electronic devices. Workers performing such tasks may routinely assemble prototypes, measure and adjust performance of devices, make necessary calculations, and perform functions related to specification development for electronic devices. Such workers may also perform some drafting functions.

☐ APPLICATION, DISTRIBUTION AND ELECTRONIC SALES: This definition refers to tasks principally associated with applications of developed devices, components, and services, and those associated with sales and distribution of electronic devices.

___ QUALITY CONTROL AND TESTING: This definition refers to tasks principally involved in measurements and adjustments of electronic devices to verify operating tolerances and specifications and to make minor modifications necessary for proper performance.

In questions 1-4 please fill in the blank with the necessary information.

1. Name _____

2. Present Job Title _____

3. Name of Employing Firm _____

4. Address of Employing Firm _____

In questions 5-6 check all the answers that apply to you.

5. In which area do you work?

6. Where did you receive your specialized occupational training?

___ 1. On the job (not apprentice)
___ 2. Apprentice
___ 3. Military
___ 4. Business College
___ 5. Trade or technical school
___ 6. Correspondence
___ 7. Specialized school (for example: private electronics school)
___ 8. High School
___ 9. Junior College
___ 10. Self taught
___ 11. Other (please list)

_____
_____
_____
_____

In questions 7-11 please circle the one answer which applies.

7. What was the highest grade of school you completed (not specialized)?

8 or less, 9, 10, 11, 12, 13, 14, 15, 16 or more

8. Sex? Male Female

9. Age? Under 20 20-30 31-50 Over 50

10. For how many years have you been in your present occupation:

Less than 1 year 1-5 years More than 5 years

11. How many times have you changed occupations in the past 5 years? (for example: plumber to electronics worker to sales = 2 changes)

0 times 1-2 times 3 or more times

EXPLANATION AND INSTRUCTIONS

Many schools offer training leading to employment in the field of electronics technology. To more clearly understand what must be known by practicing technicians, the State Boards for Vocational Education of Washington and Idaho, the University of Idaho, and Washington State University have agreed to study this important field. It is the purpose of this portion of the study to determine what facts are used by electronic technicians in their work. A questionnaire of knowledges has been prepared to determine the relationships of knowledges used in certain tasks in electronics. You will know and understand most of the knowledges listed, but we need to find which knowledges you actually need to use in the performance of your duties. By matching these knowledges with your tasks, better and more meaningful training may be planned in our schools. May we express our sincere appreciation for your cooperation in this study, and our hope that many students will benefit from your assistance.

HOW TO MARK THE QUESTIONNAIRE

If a knowledge is needed in your work, place a check (✓) in the box provided. Proceed to the next consecutive question. If a knowledge is not needed in your work, do not make any marks on that knowledge. You should then proceed to the next consecutive question. To reduce the time for filling out this questionnaire, a method of skipping "not needed" knowledges has been devised. If a number occurs adjacent to the knowledge in the "not needed" column, and the knowledge is not needed for your work, skip to the indicated number, without answering the skipped questions.

SAMPLE:

Knowledge NOT NEEDED, Go to#	Number	Knowledge NEEDED	
152	130	✓	Rectifying devices, tube and solid state
139	131		Solid state diodes, types and indicated application
	132		Ratings of solid state diodes
	133		Operating characteristics of solid state diodes, ratings and limits
	134		Characteristics of Zener diodes
	135		Ratings and limitations of solid state power rectifiers
	136		Load characteristics and regulation of solid state diodes
	137		Markings and lead identification of solid state diodes
	138		Symptoms of failure of solid state diodes
143	139	✓	Vacuum tube diodes and rectifiers
	140	✓	Ratings, types and applications of vacuum tube diodes

	141	✓	Load characteristics of vacuum tube diodes, regulation, etc
	142		Symptoms of failure of vacuum tube diodes
152	143	✓	Gas filled tubes
147	144		Characteristics of mercury vapor rectifiers

This technician needed to know about rectifying devices, but not solid state, so that he skipped from question 131 directly to 139. He did need to know about vacuum tube diodes, except that he was not concerned about tube failure in question 142. The technician is skipping to question 147 as a result of the blank in question 144. The same results would be obtained if he had not skipped, but considerable time would be spent.

Please use the blanks in the "Knowledge needed" columns on the following sheets to check (✓) the knowledges you need to do your work.

Knowledge NOT NEEDED, Go to	Number	Knowledge NEEDED	
81	1		Basic knowledges--units, currents, voltages, AC, DC, effects, etc.
16	2		Electrical units and definitions, electrical calculations
	3		Definitions of volts, amperes, watts, prefixes
8	4		Resistance of conductors
	5		Temperature effects on resistors
	6		Conductance
	7		Power consumption in resistors
13	8		Circuit and network laws
11	9		Ohm's law
	10		Series and parallel resistances
13	11		Kirchhoff's laws (mesh and nodal equations)
	12		Mesh reductions, equivalent resistances, superposition
16	13		Electrical symbols
	14		Component symbols in power applications
	15		Component symbols in electronic applications
80	16		Time-varying (AC) voltages and currents in components or circuits
26	17		Capacitances; currents, voltages, DC and AC
	18		Capacitance of plates, wires, etc.
	19		Charge on capacitors, energy stored, etc.
24	20		Reactance of capacitors
	21		Capacitive reactance calculations
	22		R-C impedance, phase effects, etc.
	23		Phase of currents and voltages in R-C circuits
	24		Time constants of R-C networks
	25		Capacitors in series, parallel, etc.
35	26		Inductances; currents, voltages, DC, and AC
	27		Self-inductance of coils, wires, etc., formulas
	28		Inductances in series and parallel

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	29		Mutual inductance, coupling, coefficients, etc.
	30		Time constants of R-L circuits
35	31		Reactance of inductors
	32		Impedance of R-L circuits
	33		Magnitude and phase of currents in R-L circuits
	34		Q of coils, effects, calculations
42	35		Impedance, voltage, current relations in R-L-C AC circuits
42	36		L-C tuned circuits
	37		Impedance, current, voltages of tuned circuits
	38		Natural frequency of tuned circuits
	39		Q of resonant circuits, Q adjustments
	40		Q of loaded resonant circuits, effects, etc.
	41		L-C ratios and effects on resonant circuits
46	42		Voltage, current effects in reactive networks, special networks, etc.
	43		Power factor
	44		L, Pi, and T networks, impedance changes, transformations
	45		Filter networks at signal frequency
	46		Voltage, currents, power in AC circuits
55	47		AC vector representations, j notation, polar forms, etc.
	48		Addition and subtraction of vectors
	49		Multiplication of vectors in j or polar form
	50		Reactive power, volt-ampere reactive
55	51		2-phase, 3-phase AC circuits, voltages, currents, line and phase
	52		Wye and Delta systems, connections, power, currents, etc.
	53		Phase currents, angles, voltages, etc., in 2- or 3-phase circuits
	54		Commercial power sources, KVA, KW, currents, regulation, etc.
71	55		Voltage, power, current generation
61	56		Batteries, cells, electrochemistry
	57		Storage batteries, operation, maintenance, limits
	58		Primary cells, internal R, life expectancy, limits, etc.
	59		Fuel cells, energy sources, internal R, operating limits, maintenance
	60		Electroplating, etching, materials, current density, etc.
71	61		Electromagnetism, permanent magnets
	62		Magnetic circuits, flux density, magnetization, total flux, mmf.
67	63		Induced voltages from magnetism
	64		Eddy currents
	65		Voltages in generators, voltage control
	66		Generators, types, windings, operation, load characteristics
71	67		Forces due to electromagnetism
71	68		Motors, starting, speed, power, operation, load characteristics
	69		Speed control of electric motors
	70		Characteristics of polyphase motors
80	71		Transient and special wave shape voltages and currents

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
82	72		Characteristics of non-sine waves, ramp, sawtooth, square, etc.
78	73		Harmonics generated in non-sine waves, rise time, overshoot, etc.
	74		Wave analysis to determine harmonic components
	75		Characteristics of square waves
	76		Characteristics of pulses, requirements, etc.
	77		Characteristics of sawtooth waves, requirements, generation, etc.
80	78		Wave shaping methods
	79		Fourier analysis
269	80		Electrical characteristics, types and kinds of individual components
89	81		Capacitors, types, characteristics
85	82		Ratings of capacitors
	83		Color codes for capacitors
	84		Tolerances for capacitors of various types
88	85		Types of capacitors
	86		Dielectrics for capacitors, advantages,of each, etc.
	87		*Life expectancy of* types of capacitors
	88		Symptoms of failure of various capacitor types
101	89		Inductors operated above power frequencies
	90		Types and specifications of signal frequency inductors
95	91		Winding methods for inductors, transformers
	92		Use of wire charts, insulations
	93		Use of inductance charts
97	94		Types and kinds of insulation for inductor windings
	95		Effects of cores in inductors, core types
	96		Core adjustments in inductors, effects on L, Q, etc.
	97		Distributed capacity of inductors
	98		Inductance formulas and calculations
	99		Resistance of coils of wire for inductances, skin effects, etc.
	100		Calculation of Q of coils from physical characteristics
116	101		Transformers, types, characteristics, principles
	102		Power transformers
	103		Ratings and loads for power transformers
	104		Symptoms of failure of power transformers
	105		Color coding schemes for power transformers
116	106		Electronic transformers, signal frequency
110	107		Input transformers
	108		Impedance transformation by transformers
	109		Color codes of electronic transformers (interstage, i.f., etc.)
116	110		Output transformers, characteristics, types and uses
	111		Power ratings and tolerances of output transformers
	112		Leakage reactance of output transformers, effects
	113		Impedance matching methods using output transformers
	114		Frequency effects and limits of output transformers
	115		Color coding and lead identification of output transformers

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
130	116		Chokes and other inductors
123	117		Types of chokes, effects of frequency, various applications
123	118		Chokes for power supplies
	119		Characteristics of swinging chokes
	120		Characteristics of smoothing chokes
	121		Resistances of windings of filter chokes, DC characteristics, effects
	122		Current and inductance ratings of filter type chokes
127	123		Radio frequency chokes
	124		Ratings and inductance values of types and kinds of RF chokes
	125		Tolerances of values for RF chokes
	126		Frequency effects of RF chokes, self resonance, etc.
130	127		Audio frequency chokes
	128		Ratings and inductance values of types and kinds of AF chokes
	129		Tolerances of values for AF chokes
152	130		Rectifying devices, tube and solid state
139	131		Solid state diodes, types and indicated applications
	132		Ratings of solid state diodes
	133		Operating characteristics of solid state diodes, ratings and limits
	134		Characteristics of zener diodes
	135		Ratings and limitations of solid state power rectifiers
	136		Load characteristics and regulation of solid state rectifiers
	137		Markings and lead identification of solid state rectifiers
	138		Symptoms of failure of solid state rectifiers
143	139		Vacuum tube diodes and rectifiers
	140		Ratings, types and applications of vacuum tube diodes
	141		Load characteristics of vacuum tube diodes, regulation, etc.
	142		Symptoms of failure of vacuum tube diodes
153	143		Gas filled tubes
147	144		Characteristics of mercury vapor rectifiers
	145		Load characteristics, limits and regulation of mercury vapor rectifiers
	146		Special precautions and operation of mercury vapor rectifiers
152	147		Thyratrons, similar gas or vapor filled tubes
	148		Ignition characteristics of thyratrons
	149		Precautions and limitations of thyratron operation
	150		Failures and detection of failure of thyratrons
	151		Characteristics and applications of voltage regulator tube types
159	152		Semi-conductor operation and construction
159	153		Operating characteristics of semi-conductors (curves, etc.)
	154		Determination of "r" parameters and their uses
	155		Determination of "h" parameters and their uses
	155a		Field effect transistor operation
	155b		SCR operation, requirements, limits, uses
	155c		Unijunction devices, techniques, applications
	156		Determination of high frequency parameters and their uses
	157		Capacitive effects of junctions, control

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	158		Bias requirements for transistor operation, thermal requirements
172	159		Receiving types of vacuum tubes and applications
	160		Characteristics of triode vacuum tubes
	161		Internal construction of vacuum tubes
	162		Internal construction of special vacuum tubes (uhf, compactrons, etc.)
	163		Characteristics of vacuum tube tetrodes and pentodes
	164		Applications of tetrodes and pentodes
	165		Characteristics and applications of multi-grid type vacuum tubes
172	166		Cathode ray and other display tubes
	167		Internal construction and requirements of cathode ray type tubes
	168		Electron ballistics in cathode ray tubes, electrostatic, electromagnetic
	169		Phosphors for display purposes in various cathode ray tubes
	170		Deflection methods and characteristics for deflection of electron beams
	171		Construction and applications of special display tubes
178	172		Transmitting tube types, applications, operation
	173		Transmitting tube characteristics, design curves, etc.
	174		Power requirements, limits of transmitting type tubes
	175		Cooling methods and protections for transmitting type tubes
	176		Special precautions and limits of operation of transmitting tube types
	177		Symptoms of failure and replacement requirements of transmitting types
188	178		Electromechanical devices and transducers, reproducers, signal sources
183	179		Microphones, signal levels, limits and operation methods
	180		Internal construction of various types of microphones
	181		Applications for various types of microphones, advantages, requirements
	182		Advantages of types of microphones, maintenance and operation
188	183		Phono pick-ups, types and uses
	184		Methods of signal sensing in phono pick-ups
	185		Output characteristics of various types of pick-ups
	186		Maintenance and care of phono pick-ups
	187		Mechanical requirements, mounting, tracking, etc., of phono pick-ups
197	188		Mechanical sensors
	189		Strain sensors, types and characteristics, signals
	190		Pressure sensors, types and characteristics
194	191		Temperature sensors
	192		Characteristics and operation of bi-metal sensors
	193		Types and operation of continuous signal sensors
197	194		Optical sensors
	195		Spectral characteristics of optical sensors
	196		Electrical characteristics of optical sensors
211	197		Speakers and other reproducers
	198		Cone type loudspeakers
	199		Magnet types and sices in loudspeakers, electrical characteristics
	200		Cone types and mountings in loudspeakers
	201		Frequency characteristics of types of loudspeakers of cone type

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	202		Baffles and resonators for cone type speakers
	203		Speaker maintenance and repair, adjustments, failure symptoms
	204		Power capabilities of cone speakers
208	205		Electrostatic speakers, operation, construction
	206		Frequency characteristics and limitations of electrostatic speakers
	207		Power requirements and supply for electrostatic speaker operation
211	208		Horns and compression type speakers
	209		Frequency characteristics of horns and horn type speakers
	210		Power capabilities and requirements for horn type speakers
221	211		Devices and methods of maintaining frequency
217	212		Piezo-electric resonators (quartz crystals for frequency control)
	213		Crystal cuts, characteristics and standards
	214		Temperature effects of quartz crystals
	215		Frequency control and adjustment of quartz crystals
	216		Crystal ovens, requirements and adjustment of operation
221	217		Methods of frequency control by magnetostriction
	218		Excitation requirements for magnetostriction oscillators
	219		Types and materials of magnetostriction frequency controls
	220		Temperature effects on magnetostriction frequency controls
257	221		Electro-mechanical devices in electronics, switches, relays, motors
232	222		Relays, types and characteristics, capacity
228	223		DC relays
	224		Coil resistance and impedance of relays
	225		Contact capabilities and limits
	226		Current and/or voltage requirements, speed of operation of relays
	227		Special DC relay types (dual winding, differential, etc.)
232	228		AC relays
	229		Coil impedance of AC relays, coil loadings, etc.
	230		Methods and principles of buzz reduction in AC relays
	231		Special types of AC relays (high current, signal frequency, reed types)
239	232		Switches
	233		Types and kinds of signal and power switches
	234		Specifications, tolerances and loads for power switches
	235		Specifications, tolerances for signal switches
	236		Special multi-contact switches, specifications and uses
	237		Current and voltage capabilities of switches and switch contacts
	238		Insulation and isolation of switches of various types
257	239		Motors, generators, DC and AC, control, speed structure
245	240		Operating characteristics of DC motors
	241		Speed control, torque control of DC motors
	242		Power requirements of DC motors, overload, cooling, etc.
	243		Maintenance requirements of DC motors
	244		Structural and winding features of DC motors
251	245		AC motors
	246		Speeds and loads of AC motors
	247		Types of motor start, characteristics (shaded pole, AC-DC, condenser)

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	248		Characteristics of types of AC motors (induction, synchronous, etc.)
	249		Maintenance requirements of AC motors, procedures
	250		Power requirements for single or polyphase motors
257	251		Principles of servo-motors and servo-devices
	252		AC selsyn servo-motors and generators, operation and supply requirements
	253		Sensitivity of servo-devices, accuracy, etc.
	254		Error detectors for servos, feedback equations, stability
	255		Gearing and other mechanical requirements for servo operation
	256		Lash reduction, effects of lash
264	257		Vibrators for power supplies
264	258		Types and operation of vibrators (synchronous and non-synchronous)
	259		Power capabilities and requirements for vibrators
	260		Load characteristics of vibrators
	261		Symptoms of failure and repair of vibrators
	262		Frequency control and adjustment of vibrators
	263		Output characteristics of vibrators
269	264		Fuses and the applications
	265		Types of fuses, limits and tolerances
	266		Fuse characteristics, time, overcurrent, protections
	267		Limitation of fuses and fused circuits
	268		Replacement standards for fuses
359	269		Knowledge of measurement techniques and devices in electronics
279	270		Principles of voltage measurement
	271		Low impedance voltage measurement techniques, AC and DC
	272		High impedance voltage measurement techniques, AC and DC
279	273		Measurement of special voltages, frequency or impedance effects
	274		Measurement of high voltages, e.g., thousands of volts
	275		Measurement of very low voltages, e.g., microvolts
	276		Measurement of RF voltages
	277		Measurement of audio frequency voltages
	278		Measurement of signals in Db or Vu
288	279		Principles of current measurement
	280		Principles of direct current measurement
	281		Alternating current measurements, audio power frequencies
288	282		Measurement of special currents, (non-sine, very small, large, etc.)
	283		Current measurements in high voltage circuits
	284		Very small current measurements (fractions of microamperes)
	285		Very large current measurements (hundreds of amperes)
	286		Video frequency current measurements
	287		Radio frequency current measurements
294	288		Principles of power measurement, AC, DC, RF, Audio, special methods
	289		DC and AC wattmeter methods
	290		Measurement of power by indirect methods
	291		Measurement of RF power

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	292		Measurement of audio or video power
	293		Measurement of power in Db
359	294		Knowledge of the uses of electronic measuring instruments
298	295		Familiarity and skill in the use of the V-O-M
	296		Applications for which V-O-M is indicated
	297		Limits of accuracy and precautions in use of V-O-M
302	298		Familiarity and skill in use of the V-T-V-M
	299		Applications for which the VTVM is indicated
	300		Limits of accuracy of the VTVM
	301		Symptoms of failure of the VTVM
315	302		Familiarity and skill in the use of the oscilloscopes
315	303		Applications of single trace oscilloscopes
	304		Principles of operation of oscilloscopes, loading, impedance, etc.
	305		Limitations on uses, accuracy, frequency response of oscilloscopes
	306		Methods of frequency measurement by oscilloscope
	307		Methods of measurement of pulse times, phase, etc., by oscilloscope
	308		Measurements of DC by oscilloscope
	309		High frequency oscilloscope measurement
	310		Triggering methods, control methods, etc., in operating oscilloscopes
	311		Peak to peak measurements and interpretations on the oscilloscope
315	312		Applications and operation of dual trace oscilloscopes
	313		Measurement methods of time, phase, distortion, etc., on dual trace oscilloscope
	314		Methods of measuring gain, wave shape, etc., on dual trace oscilloscope
325	315		Operation of bridges and special measuring equipment (moderate accuracy
	316		Operation of R-L-C checkers
	317		Operation of simple Q meters
	318		Operation of grid dip meters
	319		Operation of standing wave meters or bridges, SW ratio meters
	320		Operation of tube testers
	321		Operation of absorption frequency meters
	322		Operation of field strength meters
	323		Operation of modulation index indicators, modulation meters
	324		Operation of frequency deviation meters
339	325		Operation of precision measuring equipment, precision measurements
	326		Operation of precision RF bridge
330	327		Operation and uses of transistor characteristics display apparatus
	328		Measurement of low frequency parameters of transistors
	329		Measurements for transistor selection of matching
	330		Measurements of high frequency transistor parameters, jigs, etc.
335	331		Measurement of tube characteristics on oscilloscope
	332		Measurement of mu, plate resistance, transconductance by precise means
	333		Measurement of emission of vacuum tubes
	334		Measurement of interelectrode capacitance

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	335		Measurement of R, L, and C by the precise type Q meter
	336		Operation and measurements by using distortion analyzers, meters
	337		Harmonic amplitude measurements using wave analyzers
	338		Operation and measurements by phase meter
344	339		Operation and applications of laboratory standards, precision measures
	340		Operation of RF generator
	341		Operation of AF generator
	342		Operation of pulse generators
	343		Operation and uses of sweep generators
359	344		Operation and applications of laboratory standards, precision measures
348	345		Uses and types of frequency standards
	346		Calibration and standardization of frequency using frequency standards
	347		Operation and normal adjustment of laboratory local frequency standard
	348		Care and application of resistance standards
	349		Standardization and precision resistance measurements
354	350		Care and application of capacitance standards
	351		Standardization and precision capacitance measurements
	352		Precision measures of L, k, and M using precision capacitance
	353		Calibration and standardization of instruments using standard capacitor
356	354		Care and application of standards of inductance
	355		Precision measures of L, k, and M by comparison methods
359	356		Care and application of standard cells
	357		Precision voltage measurements using bridges or potentiometer
	358		Instrument calibration by using precision voltage sources
468	359		Knowledges of circuits, applications (one or two tubes or transistors)
399	360		Knowledge of circuits for amplifiers with tubes
370	361		Operating conditions for amplifier circuits with tubes
	362		Calculations and methods to obtain grid bias
	363		Calculations and methods to obtain screen supply
	364		By-passing calculations to obtain desired frequency response
	365		Calculations to obtain gain of tube amplifiers
	366		Requirements and controls to gain stability of circuits
	367		Methods and requirements for coupling tube circuits
	368		Uses of resistance coupled amplifier charts
	369		Input and output impedance calculations of vacuum tube amplifiers
380	370		Knowledge of circuits for semi-conductor amplifiers
380	371		Operating conditions of transistor amplifiers
	372		Bias methods and calculations for transistor amplifier biasing
	373		Stabilization calculations and methods for transistor amplifiers
	374		Current and voltage gains in transistor amplifiers
	375		Frequency limits and causes in transistor amplifiers
	376		Blocking and by-pass requirements and calculations in transistor circuits
	377		Gain, impedance, of common emitter, base, or collector circuits

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	378		Coupling methods in transistor amplifiers
	379		Methods of determining input, output, and transforming impedances with transistor amplifiers
399	380		Operating principles of tuned amplifiers, pass band, broad band
389	381		Principles of operation of single tuned amplifiers, bandwidth, etc.
	382		Principles of operation of narrow band amplifiers
	383		Broad-band amplifier principles, peaking methods, single tuned
	384		Coupling methods for tuned amplifiers
	385		Neutralizing tuned amplifiers, singly tuned
	386		VHF circuit principles and special techniques
	387		UHF circuit principles and special techniques
	388		Parasitics and oscillations, sources, suppression, etc.
399	389		Principles of multiple tuned amplifiers
	390		Impedance matching, coupling in multiple tuned amplifiers
	391		Tuning methods, Pi sections, cavities, lines
	392		Broad-band amplifier principles, multiple tuned, frequency centers for stagger tuning
	393		Biasing methods in tuned transmitting circuits
	394		Excitation methods and requirements in transmitting circuits
	395		Driving and output impedances of transmitting circuits
	396		Neutralization methods in multiple tuned transmitting circuits
	397		Balanced RF amplifier principles
	398		Limiter amplifier principles
402	399		Principles of direct coupled amplifiers
	400		Methods of stabilization of direct coupled amplifiers
	401		Special applications of direct coupled amplifiers
428	402		Principles of detection, modulation and mixing
413	403		Detector operating principles
	404		Types of diode demodulators
	405		Methods of DC recovery from demodulated signals
	406		Biased detector operating principles
	407		Grid or base detection principles
	408		Plate or collector detection principles
	409		Discriminators and FM detection methods and circuits
	410		Ratio detection and FM detection methods
	411		Linear detector principles
	412		Square-law detector principles
419	413		Heterodyning principles and methods
	414		Pentagrid converter operation
	415		Transistor first detector methods and circuits, problems
	416		Vacuum tube first detector methods and circuits
	417		Signal filtering methods
	418		Crystal controlled converter circuits and operation
428	419		Modulator operating principles
	420		Methods of plate (collector) modulation and principles

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	421		Methods of grid (base) modulation and principles
	422		Suppressor and/or screen modulation principles
	423		Determination of modulation impedance, and modulation power
	424		Phase or frequency modulation methods and circuit operation
	425		Reactance tube circuit operation, principles
	426		Determination of modulation index, modulated power, etc.
	427		Velocity modulation methods and circuit operation
438	428		Oscillator operating principles
438	429		Types of self-excited oscillator circuits
	430		Principles of crystal controlled oscillators
	431		R-C and negative resistance oscillators, operating principles
	432		Principles and operation of klystron oscillators
	433		Special high frequency oscillator circuits
	434		Tunnel diode oscillator circuits
	435		Principles of multivibrator circuits
	436		Principles of relaxation oscillator circuits
	437		Principles of stabilization of oscillators
444	438		Wave shaping circuitry, counters and flip-flop circuit operation
	439		Principles of differentiators and integrators
	440		Methods of clipping and biasing of diodes for wave shaping
	441		Methods of clipping with multielement tubes or transistors
	442		Methods of DC restoration, clamp circuits
	443		Circuits suitable for counting, logic (and, nand, nor, etc.)
468	444		Knowledges of power supplies, rectifier circuits
456	445		Types and kinds of rectifier circuits
	446		Operation of one-half wave rectifiers
	447		Operation of full-wave rectifiers
	448		Operation of high voltage rectifiers, special circuits, etc.
454	449		Operation of higher current rectifiers
	450		Operation of mercury vapor rectifiers
	451		Determination of inverse voltages in rectifiers, tube choice, etc.
	452		Insulation and safety requirements for power supply systems
	453		Circuits for overcurrent and undervoltage protection
	454		Operation of multiphase rectifiers
	455		Operation of voltage multiplier rectifiers
461	456		Principles of operation of power supply filters
	457		Effects upon regulation of filters in power supplies
	458		Principles of operation of condenser input filters, regulation
	459		Principles of operation of choke input filters, regulation
	460		Determination of bleeder requirements and effects
464	461		Principles of rectifier controls
	462		Methods and circuits for voltage control
	463		Methods and circuits for current control
468	464		Principles and methods of operation of inverters

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	465		Operation of vibrator supplies
	466		Operation of transistor supplies
	467		Operation of motor-generator or genemotor power supplies
521	468		Knowledges of electronic systems, operation, installation, etc.
476	469		Principles of operation of amplifiers and amplifier systems
	470		Applications and operation of audio amplifier units
	471		Applications and operation of video amplifier units
	472		Applications and operation of IF amplifier units
	473		Applications and operation of operational amplifiers
	474		Applications and operation of DC amplifiers
	475		Applications and operation of VHF distribution amplifiers
	476		Principles of operation of power supply systems, units
484	477		Principles of operation of radio transmitters
	478		Operation and adjustment of AM communication transmitters
	479		Operation and adjustment of AM broadcasting transmitters
	480		Operation and adjustment of FM communication transmitters
	481		Operation and adjustment of FM broadcasting transmitters
	482		Operation and adjustment of microwave transmitters
	483		Operation and adjustment of translators and broadcast repeaters
	484		Principles of operation and adjustment of speech and video systems
	485		Operation of speech consoles
	486		Operation of video consoles
	487		Operation of TV cameras
	488		Operation of monitor systems
	489		Operation of disk recorders
	490		Operation of audio magnetic recording systems
	491		Operation of video magnetic recording systems
	492		Operation of digital magnetic recording systems
	493		Operation of tone keyers and other signal systems
502	494		Principles of operation and adjustment of receiving equipment
	495		Operation of AM receiver systems
	496		Operation of FM receivers
	497		Operation of TV receivers
502	498		Operation of communications and special receivers
	499		Operation of communications AM receivers (complex types)
	500		Operation of communications FM receivers (complex types)
	501		Operation of pulse reception systems
521	502		Operation principles and adjustment of special receivers
510	503		Operation of computing and computing type control systems
	504		Operation of digital electronic systems
	505		Operation of analog electronic systems
	506		Operation of electronic-hydraulic control systems
	507		Operation of electronic-mechanical control systems
	508		Operation of special manufacturing electronic control systems
	509		Operation of servo-mechanical systems
516	510		Principles of operation and adjustment of wired communications or entertainment systems

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
	511		Operation of community antenna television systems
	512		Operation of complex inter-communication systems
	513		Operation of sound and/or video laboratory systems
	514		Operation of telephone communication systems
	515		Operation of music distribution systems
521	516		Principles of operation of wired or wireless pulse systems
	517		Operation of radar systems
	518		Operation of sonar systems, depth-finder systems
	519		Operation of ranging or rangefinder systems
	520		Operation of aids to navigations systems, air or marine
577	521		Knowledge of waves, transmission lines and propagation of waves
529	522		Knowledge of the nature and characteristics of electromagnetic waves
	523		Effects of polarization of electric waves
	524		Effects of reflection of electric waves
	525		Effects of refraction of electric waves
	526		Effects of spreading of waves, strength of signals with distance, etc.
	527		Absorption characteristics of electric waves
	528		Field strength characteristics of waves
550	529		Principles of transmission lines
538	530		Determination and understanding of characteristic impedance of lines
	531		Determination of characteristic impedance of co-axial lines
	532		Characteristic impedance of open wire lines
	533		Choice of conductor size and effects on characteristic impedance
	534		Choice of dielectric and effect on characteristic impedance of lines
	535		Characteristics and limitations in use of flat lines
	536		Transmission characteristics of waves in guides
	537		Effects and determination of critical frequency in wave guide transmission
547	538		Principles of line termination
	539		Methods of measurement and calculation of input impedance in lines
	540		Termination methods and principles of tuned lines
	541		Termination methods and principles of untuned lines
	542		Methods of impedance matching for input and output of lines
	543		Methods of impedance matching using baluns
	544		Methods of impedance matching using stub lines
	545		Measurement, detection and control of standing waves on lines
	546		Principles of impedance transformation by lines
550	547		Principles involved in making applications of lines
	548		Calculations and considerations involving line attenuation
	549		Determinations necessitating use of pre-amplifiers and line boosters
554	550		Principles, methods and construction in using wave guides and horns
	551		Factors limiting frequency in wave guides and horns
	552		Operation of attenuators in wave guides
	553		Techniques for tuning and matching wave guides

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
577	554		Principles of wave propagation by antennas and antenna systems
564	555		Characteristics of antenna types and selection of antenna types
	556		Electrical characteristics of open wire antennas
	557		Electrical characteristics of simple dipole antennas
	558		Electrical characteristics of folded dipole antennas
	559		Electrical characteristics of broad band and array antennas
566	560		Principles of multi-element and parasitic element antennas
	561		Electrical characteristics of Yagi antennas
	562		Types of special high frequency transmitting antennas
	563		Characteristics and operation of dish reflector type antennas
	564		Electrical characteristics of vertical antennas and systems
	565		Electrical characteristics of mobile and small power antennas
576	566		Characteristics of radiation from antennas and antenna systems
	567		Radiation angle effects of antennas
	568		Radiation patterns of antennas and antenna systems
	569		Impedance and impedance adjustment of antennas
	570		Balancing and matching of antennas and antenna systems
	571		Radiation resistances of antennas and antenna systems
	572		Measurement and plotting field strength of antenna systems
	573		Loading methods and techniques of antennas
	574		Operation and principles of loading coils in antennas
	575		Techniques of matching vertical antennas
	576		Standards and codes for antenna installation and construction
631	577		Electronic-related knowledges, procedures, methods, construction
605	578		Procedures of electronic construction
594	579		Tools, materials and methods of electronic construction
588	580		Methods of chassis or cabinet and panel preparation
	581		Drill sizes for various materials, various purposes
	582		Taps and methods of using taps in electronic construction
	583		Use of hole punches, saws, and nibblers in chassis preparation
	584		Techniques of sheet metal forming, bending
	585		Use of welders and welding techniques in chassis or cabinets
	586		Uses and applications of paints, finishes in electronics
	587		Methods of stamping, marking, screening and/or electronic labeling
593	588		Techniques of wiring and cabling in electronic construction
	589		Knowledge of resistor color code
	590		Knowledge of condenser color codes
	591		Systems of lead identification of transformers, chokes, etc.
	592		Systems of conductor identification and cable and wire codes
599	593		Uses, preparations and methods for use in printed circuits
	594		Assembly methods for printed circuit boards
	595		Parts assembly on printed circuit boards, hand or machine
	596		Preparation or production of printed circuit boards
	597		Chemical treatment and methods of circuit board manufacture
	598		Inspection and protection of printed circuit boards

Knowledge NOT NEEDED, Go to #	Number	Knowledge NEEDED	
609	599		Knowledge of electronic drafting, illustrating, other drafting
604	600		Principles of mechanical drawing
	601		Production of chassis layout drawings, panel drawings, etc.
	602		Design drawings of parts and components
	603		Pictoral drawings used in electronics
608	604		Knowledge of electronic or electrical circuit drafting
	605		Pictoral or schematic circuit drafting principles and techniques
	606		Techniques and methods for printed circuit drafting
	607		Methods of curve plotting and similar technical displays
	608		Methods and materials of print making and reproduction
619	609		Knowledge of principles of mobile, aircraft or marine installations
	610		Techniques and requirements of grounding and bonding
614	611		Principles of noise reduction
	612		Methods of shielding for noise reduction
	613		Methods and materials for ignition noise reduction
619	614		Knowledges related to mobile and similar power sources
	615		Principles of battery maintenance, choice and installation
	616		Principles of motor-generator maintenance, choice and installation
	617		Principles of transistor supplies, maintenance and operation
	618		Principles of vibrator supplies, maintenance, operation or installation
630	619		Special knowledges for electronic writing, written communication
	620		Techniques of descriptive writing for electronics
	621		Techniques of data presentation used in electronic writing
	622		Techniques in writing equipment specifications
626	623		Techniques and principles in writing instructions
	624		Techniques of writing equipment operation instructions
	625		Techniques of writing assembly and/or construction instructions
	626		Techniques and methods of writing reports
	627		Uses of photography and drawings in technical writing
	628		Special techniques in writing technical electronic reports
	629		General techniques of report writing
	630		Specific knowledges leading to licensing, and possession of license
637	631		Special knowledges leading to licensing, and possession of license
	632		Use of first-class phone commercial license
	633		Use of second-class phone commercial license
	634		Use of third- or other similar federal license
	635		Use of first or second radiotelegraph license
	636		Use of local or state or other non-federal license
	637		Knowledge of procedures or methods for instrument movements
	638		Methods of repair of instrument movements
	639		Methods and techniques of instrument recalibration

APPENDIX B

KNOWLEDGE ITEMS DEEMED NECESSARY FOR PERFORMANCE
BY 90 PER CENT OF RESPONDENTS

Item Number	Principal Tasks 1	2	3	4	5	6	7	8
See Check List, pages 33-50 for names of items denoted by numbers	Diagnosing trouble	Adjusting and/or operating	Servicing	Assembling	Installing	Designing and computation	Application, distribution and sales	Quality control and testing
1	x	x	x	x	x	x	x	
2	x	x			x	x	x	
3	x	x	x			x	x	
4	x	x			x	x		
5						x		
7		x				x		
8	x	x				x		
9	x	x	x		x	x		x
10	x	x			x	x		x
13	x		x		x	x		x
15	x		x		x	x		x
16						x		
17	x	x				x		x
20		x				x		
21						x		
22		x						
24		x				x		x
25		x				x		
26		x				x		
30		x						
31		x				x		
32		x						

Item Number	Principal Tasks 1	2	3	4	5	6	7	8
See Check List, pages 33-50 for names of items denoted by numbers	Diagnosing trouble	Adjusting and/or operating	Servicing	Assembling	Installing	Designing and computation	Application, distribution and sales	Quality control and testing
35		x				x		
36		x				x		
45		x						
46		x						
72						x		
75						x		
80	x	x				x		x
81	x	x				x	x	x
82	x	x				x	x	x
83		x				x		
84		x				x		
85		x				x		
86						x		
88		x						x
89		x						
101		x				x		
102								x
106		x						
107		x						
108		x						
110		x						
114		x						

Item	Principal Tasks 1	2	3	4	5	6	7	8
116		x						
117		x						
118		x						
121		x						
130	x	x				x	x	x
131		x				x		x
132		x				x		
133		x						
134		x				x		
135		x						
136		x						
137		x					x	
138		x						
139		x					x	
140		x						
141		x						
142		x						
152		x				x		
153		x				x		
159		x						
160		x						
163		x						
164		x						
165		x						
166		x						
172		x						
175		x						
176		x						
177		x						
179		x						
197		x						
211		x						
212		x						
216		x						
222		x						x
223	x	x						x
228		x						
232		x						x
233		x						
264		x				x		
265		x				x		
268		x						
269	x	x	x			x		x
270		x	x			x		x
271								x

Item	Principal Tasks 1	2	3	4	5	6	7	8
274	x	x						
277		x						
279		x				x		
280		x				x		
288		x				x		
291		x						
293		x						
294		x				x		
295		x						
298		x			x	x		
299		x	x			x		
300		x				x		
301		x						
302	x	x				x		x
303		x				x		x
304		x				x		x
305						x		
306						x		x
307						x		
310						x		x
311						x		x
312						x		x
313						x		
315						x		
316						x		
320	x							
322	x							
339	x					x		
341	x					x		
359	x					x		
360	x							
361	x							
362	x							
363	x							
364	x							
371						x		
380	x							
381	x							
398	x							
399	x							
402	x							
403	x							
406	x							
413	x							
416	x							

Item	Principal Tasks 1	2	3	4	5	6	7	8	Item	Principal Tasks 1	2	3	4	5	6	7	8
417		x							477		x						
419		x							485		x						
428		x							490		x						
430		x							495		x						
444		x	x			x			529		x						
445		x	x			x			531		x						
446		x				x			538		x						
447		x				x			578						x		
448		x							579		x				x		
450		x							580						x		
452		x							581						x		
456		x							582						x		
457		x							583						x		
458		x							584						x		
459		x							588		x				x		
460		x							589		x				x		
468		x							590		x						
469		x							593						x		
470		x							631		x						
									632		x						

APPENDIX C

KNOWLEDGE ITEMS DEEMED NECESSARY FOR PERFORMANCE OF PRINCIPAL TASKS BY 60-89 PER CENT OF RESPONDENTS

Item Number	Principal Tasks 1	2	3	4	5	6	7	8
See Check List, pages 33-50 for names of items denoted by numbers	Diagnosing trouble	Adjusting and/or operating	Servicing	Assembling	Installing	Designing and computation	Application, distribution and sales	Quality control and testing
1	x	x	x	x	x	x	x	x
2	x	x	x	x	x	x	x	x
3	x	x	x	x	x	x	x	x
4	x	x	x	x	x	x		x
5	x	x	x		x	x		x
6	x	x	x		x	x		x
7	x	x	x	x	x	x		x
8	x	x	x	x	x	x		x
9	x	x	x	x	x	x		x
10	x	x	x	x	x	x		x
11						x		
12						x		
13	x	x	x	x	x	x	x	x
14	x	x						x
15	x	x	x	x	x	x		x
16	x	x			x	x		x
17	x	x	x		x	x		x
18	x	x				x		x
19	x	x				x		x
20	x	x				x		x

Item Number	Principal Tasks 1	2	3	4	5	6	7	8
See Check List, pages 33-50 for names of items denoted by numbers	Diagnosing trouble	Adjusting and/or operating	Servicing	Assembling	Installing	Designing and computation	Application, distribution and sales	Quality control and testing
21		x				x		x
22	x	x				x		x
23	x	x				x		x
24	x	x				x		x
25	x	x	x	x	x	x		x
26	x	x	x		x	x		x
27	x	x				x		x
28	x	x	x			x		x
29		x				x		x
30	x	x				x		x
31	x	x		x		x		x
32	x	x				x		x
33		x				x		x
34	x	x				x		
35	x	x				x		x
36	x	x				x		x
37	x	x				x		
38	x	x			x	x		x
39		x				x		
40		x				x		

Item	Principal Tasks 1	2	3	4	5	6	7	8
41		x				x		
42	x	x				x		x
43		x				x		
44	x	x				x		
45	x	x	x			x		x
46	x	x				x		x
47		x				x		
48	x	x				x		
49		x						
50		x						
51	x	x						
52	x	x			x			
53		x						
54		x						
55	x	x				x		x
56		x		x				
57		x						
58		x						
61	x	x						x
62		x						
63		x				x		
68		x						
71	x	x				x		x
72	x	x				x		x
73	x	x				x		x
74	x	x				x		x
75	x	x				x		x
76	x	x				x		x
77	x	x				x		x
78	x	x				x		x
80	x	x	x	x	x	x	x	x
81	x	x	x	x	x	x	x	x
82	x	x	x	x	x	x	x	x
83	x	x	x	x	x	x	x	x
84	x	x	x	x	x	x	x	x
85	x	x	x	x	x	x	x	x
86	x	x				x		x
87		x				x		
88	x	x	x		x	x		x
89	x	x				x		x
90		x				x		x
91		x				x		
92		x				x		
93		x				x		
94						x		
95		x				x		x

Item	Principal Tasks 1	2	3	4	5	6	7	8
96		x						
97		x				x		
98		x				x		x
99		x						x
101	x	x	x		x	x		x
102	x	x	x		x	x		x
103	x	x	x		x	x		x
104	x	x	x		x	x		x
105		x	x		x	x		
106	x	x			x	x		x
107	x	x			x	x		x
108	x	x			x	x		
109			x		x			
110	x	x	x		x	x		x
111		x	x					
113		x			x	x		
114		x					x	
115		x	x		x			
116	x	x	x		x	x	x	x
117	x	x	x		x	x		x
118	x	x	x		x	x		x
119		x						
120		x						
121		x				x		
122		x	x			x		
123	x	x	x		x	x		
124		x				x		
125		x						
126		x				x		
127		x	x		x			
128		x						
129		x						
130	x	x	x	x	x	x	x	x
131	x	x	x	x	x	x	x	x
132	x	x	x	x		x	x	x
133	x	x	x	x		x	x	x
134	x	x	x	x		x	x	x
135	x	x	x			x	x	x
136		x	x			x		x
137	x	x	x	x	x	x	x	x
138	x	x	x	x	x	x		x
139	x	x	x		x		x	
140	x	x	x		x			
141		x						
142	x	x	x		x			
143	x	x						

Item	Principal Tasks 1	2	3	4	5	6	7	8
144		x						
145		x						
146		x						
147	x	x						
148		x						
149		x						
150		x						
151	x	x						
152	x	x		x	x	x		x
153	x	x				x		x
155						x		
155a		x				x		x
155b		x				x		x
155c		x				x		x
157						x		
158		x				x		x
159	x	x	x		x		x	
160	x	x	x		x			
161		x	x		x			
162		x	x					
163	x	x	x		x			
164		x	x		x			
165	x	x	x		x			
166	x	x	x			x		
167		x	x					
169		x						
170	x	x	x					
172		x						
173		x						
174		x						
175		x						
176		x						
177		x						
178	x	x						x
179		x			x			
180		x						
181		x			x			
182		x			x			
183		x	x					
184		x	x					
185		x	x					
186		x	x					
187		x	x					
191						x		
197		x	x		x			
198		x	x					

Item	Principal Tasks 1	2	3	4	5	6	7	8
199		x	x					
200		x	x					
201	x	x	x					
202		x	x					
203		x	x					
204		x	x					
208		x	x					
209			x					
211		x			x	x		
212		x						
213		x						
214		x						
215		x						
216		x						
221	x	x	x	x		x		x
222	x	x	x	x	x	x		x
223	x	x		x	x	x		x
224	x	x				x		x
225	x	x				x		x
226	x	x				x		x
227		x						x
228	x	x				x		x
229	x	x						
230		x						
231		x						x
232	x	x		x	x	x		x
233	x	x				x		x
234		x						
235		x				x		
236		x		x		x		x
237	x	x				x		x
238	x	x				x		x
239		x						
243		x						
245	x	x						
246		x						
247		x						
248		x						
249		x						
250		x						
251	x							
257		x	x			x		
258			x					
264	x	x	x	x	x	x	x	x
265	x	x	x		x	x	x	x
266	x	x	x		x	x		x

Item	Principal Tasks 1	2	3	4	5	6	7	8
267	x	x	x		x	x		x
268	x	x	x		x			x
269	x	x	x	x	x	x		x
270	x	x	x	x	x	x		x
271	x	x	x	x	x	x		x
272	x	x	x	x	x	x		x
273	x	x			x	x		x
274	x	x	x			x		x
275	x	x		x	x	x		x
276	x	x	x		x	x		x
277	x	x	x	x	x	x		x
278	x		x		x	x		x
279	x	x	x	x	x	x		
280	x	x	x	x	x	x		x
281	x	x	x		x	x		x
282		x				x		x
283		x						x
284	x					x		x
287		x						
288	x	x			x	x		
289		x				x		
290		x				x		
291		x						
292		x						
293		x			x	x		
294	x	x	x	x	x	x		x
295	x	x	x	x	x	x		x
296	x	x	x	x	x	x		x
297	x	x	x	x	x	x		x
298	x	x	x	x	x	x		x
299	x	x	x	x	x	x		x
300	x	x	x	x	x	x		x
301	x	x	x	x	x	x		
302	x	x	x	x	x	x		x
303	x	x	x	x	x	x		x
304	x	x	x	x	x	x		x
305	x	x	x	x		x		x
306	x	x	x	x		x		x
307	x	x		x		x		x
308	x	x				x		x
309	x	x		x		x		x
310	x	x		x		x		x
311	x	x	x	x		x		x
312	x	x		x		x		x
313	x	x				x		x
314	x	x				x		x

Item	Principal Tasks 1	2	3	4	5	6	7	8
315	x	x				x		x
316		x				x		x
317		x				x		
318		x						
319		x						
320		x	x		x			
321		x						
322		x						
323		x						
324		x						
325		x				x		x
326		x						
327						x		x
328						x		
329						x		
336	x					x		
339	x	x	x		x	x		x
340	x	x	x		x	x		x
341	x	x	x		x	x		x
342	x	x				x		x
343	x	x	x					
344						x		
359	x	x	x	x	x	x		x
360	x	x	x	x	x	x		
361	x	x	x		x	x		
362		x	x					
363		x	x					
364		x						
365		x						
366		x						
367		x	x					
368		x						
369		x			x			
370	x	x	x	x	x	x		x
371	x	x	x	x	x	x		x
372		x	x			x		x
373						x		
374		x	x	x		x		x
375		x				x		x
376		x				x		
377		x	x			x		x
378		x	x		x	x		
379		x				x		
380	x	x	x		x	x		
381		x	x		x			
382		x						

Item	Principal Tasks 1	2	3	4	5	6	7	8
383		x	x					
384		x	x					
385		x						
386		x	x		x			
387		x						
388		x	x					
389		x						
390		x						
391		x						
392		x						
393		x						
394		x						
395		x						
396		x						
397		x						
398		x						
399	x	x				x		
400		x				x		
401		x						
402	x	x				x		
403	x	x	x					
404		x	x					
405		x			x			
406		x						
407		x						
408		x						
409		x	x					
410		x	x					
411		x						
412		x						
413		x	x					
414		x	x					
415		x						
416		x						
417		x						
418		x						
419		x						
420		x						
421		x						
422		x						
423		x						
424		x						
425		x						
428	x	x	x			x		
429	x	x	x			x		
430		x	x					

Item	Principal Tasks 1	2	3	4	5	6	7	8
431		x						
435	x	x	x					
436		x				x		
437	x	x	x			x		
438	x	x				x		x
439			x			x		
440	x	x				x		
441	x	x						
442	x	x						
443					x			
444	x	x	x	x	x	x		x
445	x	x	x		x	x		x
446	x	x	x		x	x		x
447	x	x	x	x	x	x		x
448	x	x	x					
449		x				x		
450		x						
451		x						
452		x						
453		x						
454		x						
455		x						
456	x	x	x		x	x		x
457	x	x			x	x		
458	x	x	x		x	x		
459	x	x	x		x	x		
460		x	x			x		
461	x	x				x		
462	x	x				x		x
463	x	x				x		x
464		x						x
465		x	x					
466	x	x	x					x
467		x						
468	x	x			x	x		
469	x	x	x		x			x
470	x	x	x		x			
471		x	x					
472	x	x	x					
473		x				x		
474	x	x				x		
475		x						
476		x	x					
477		x						
478		x						
479		x						

Item	Principal Tasks 1	2	3	4	5	6	7	8
480		x						
481		x						
482		x						
484		x						
485		x						
486		x						
488		x						
490		x						
491		x						
494		x	x					
495		x	x					
496		x	x					
497		x	x					
498		x						
500		x						
521		x				x		
522		x						
523		x						
524		x						
525		x						
527		x						
528		x						
529		x			x			
530		x						
531		x			x			
532		x			x			
533		x						
534		x						
535		x						
538		x			x			
539		x						
540		x			x			
541		x						
542		x			x			
544		x						
545		x						
546		x						
547		x						
548		x						
554		x			x			
555		x	x		x			
556		x						
557		x	x		x			
558		x	x		x			
559		x	x		x			
560		x	x		x			
561			x		x			

Item	Principal Tasks 1	2	3	4	5	6	7	8
566		x			x			
567		x						
568		x	x					
569					x			
572		x						
573		x						
577				x		x		
578		x		x		x		
579		x		x		x		x
580		x		x		x		
581		x		x		x		
582		x		x		x		
583		x		x		x		
584				x		x		
586				x		x		
587		x		x		x		
588	x	x		x	x	x		
589	x	x	x	x		x		x
590		x	x	x		x		
591		x	x	x		x		
592		x		x		x		
593			x	x		x		
594		x		x		x		
595		x		x		x		
596				x				
598		x		x				
599		x		x		x		
600						x		
601				x		x		
602				x				
603				x		x		
604		x				x		
605				x		x		
607		x				x		
610		x				x		
611		x		x	x	x		
612		x				x		
615		x						
617		x						
618		x						
619						x		
623						x		
630		x						
631		x						
632		x						
637		x						
639	x							

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4. SOURCE: U.S. Dept. of Health, Education, and Welfare Office of Education, Bureau of Research Final Report (6/65 - 12/66)	
5. TITLE: Major Task and Knowledge Clusters Involved in Performance of Electronic Technicians' Work. Project No. ERD-257-65	
6. AUTHOR(S): Mills, Boyd C., and Rahmlow, Harold F.	
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15. ABSTRACT (250 words max.)

Purpose: To identify specific knowledges and clusters of knowledges most widely useful in major types of work commonly done by electronic technicians.

Procedure: Principle tasks of technicians were classified as diagnosing trouble in systems; adjusting and/or operating; servicing; assembling; installing; designing and computing; application, distribution, and sales in electronics; and quality control and testing. A questionnaire listing 643 knowledges extracted from textbooks, curriculum guides, and courses of study was administered to a sample of workers in 64 establishments broadly representative of the national pattern of electronic technicians' work.

Results: Technicians deemed 84 of the 643 knowledges essential for performance of six of the eight principle tasks and 154 essential forperformance of three to five principle tasks.

16. RETRIEVAL TERMS (Continue on reverse)

	Knowledge clusters Task clusters Electronic technician Vocational education Curriculum, Vocational Ed. Curriculum, Vocational		Curriculum, community college Technician, electronic

17. IDENTIFIERS

Vo-Tech. R and D Project ERD-257-65	

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16. RETRIEVAL TERMS (Continued)

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